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(54) **ONBOARD TERMINAL DEVICE AND TRAFFIC CONTROL SYSTEM**

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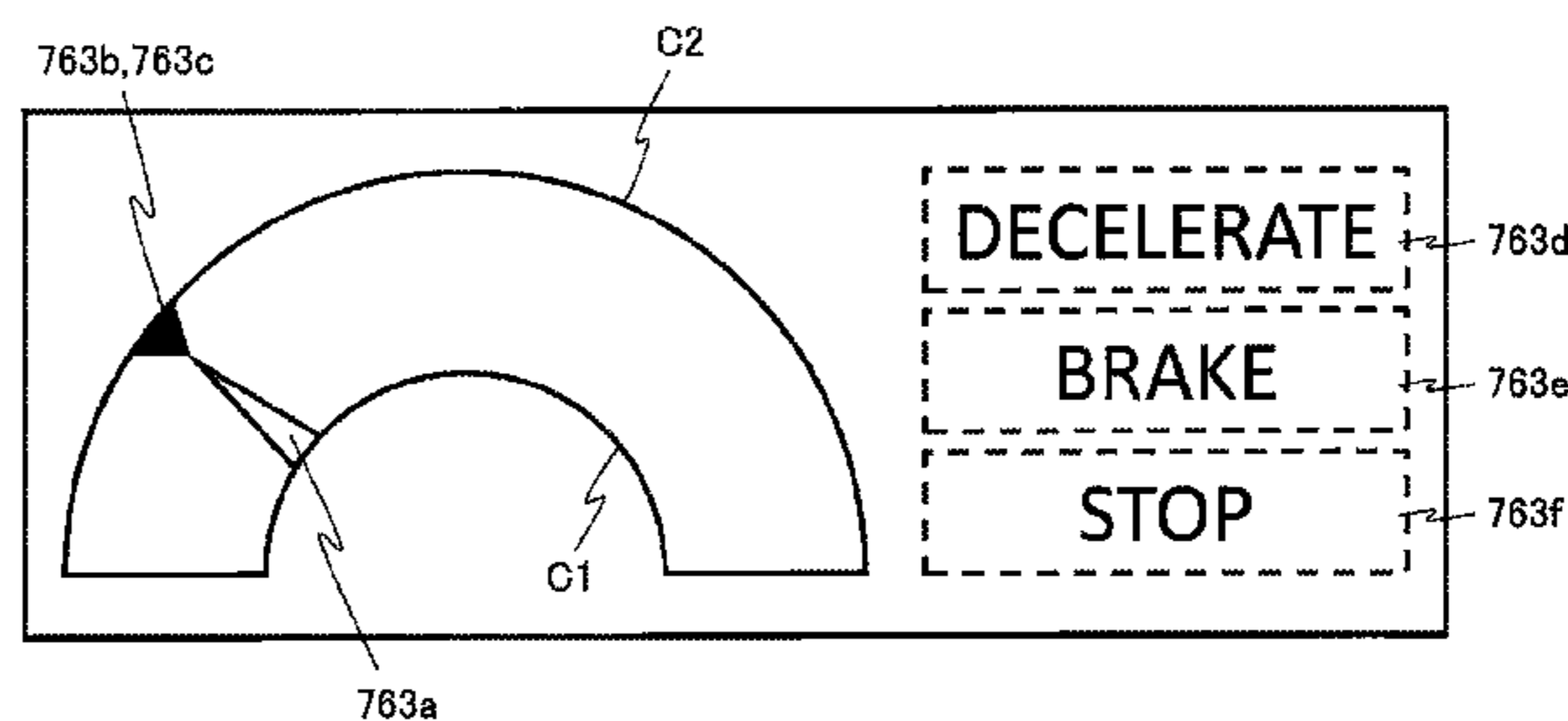
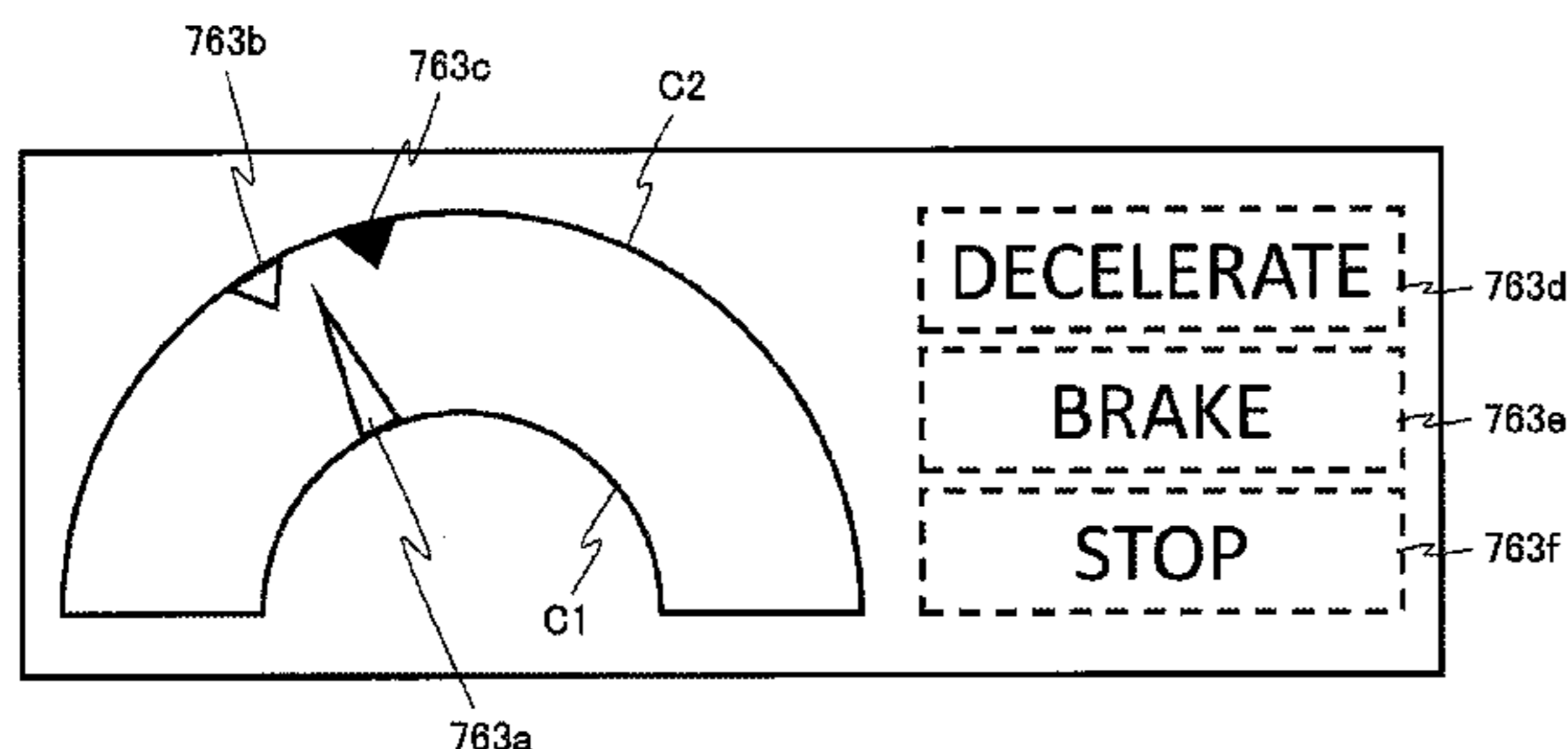
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(74) *Attorney, Agent, or Firm* — Mattingly & Malur, PC

(57) **ABSTRACT**

A terminal side control device that executes processing for instructing travel of a vehicle to a driver on the basis of a travel permission section assigned thereto by a control server. The terminal-side control device includes: a remaining distance calculation unit that calculates a travel permission remaining distance on the basis of the present position of the own vehicle acquired from a position calculation device and the travel permission section; an upper limit speed calculation unit that calculates an upper limit speed of the own vehicle in the travel permission section on the basis of the travel permission remaining distance calculated by the remaining distance calculation unit; and a display control unit that causes a terminal side display device to output and present to the driver the upper limit speed calculated by the  
(Continued)



upper limit speed calculation unit and predetermined warning information corresponding to the upper limit speed.

**7 Claims, 13 Drawing Sheets**

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*G08G 1/015* (2006.01)  
*G08G 1/052* (2006.01)  
*E21C 47/00* (2006.01)  
*G08G 1/0967* (2006.01)
- (52) **U.S. Cl.**  
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FIG. 1

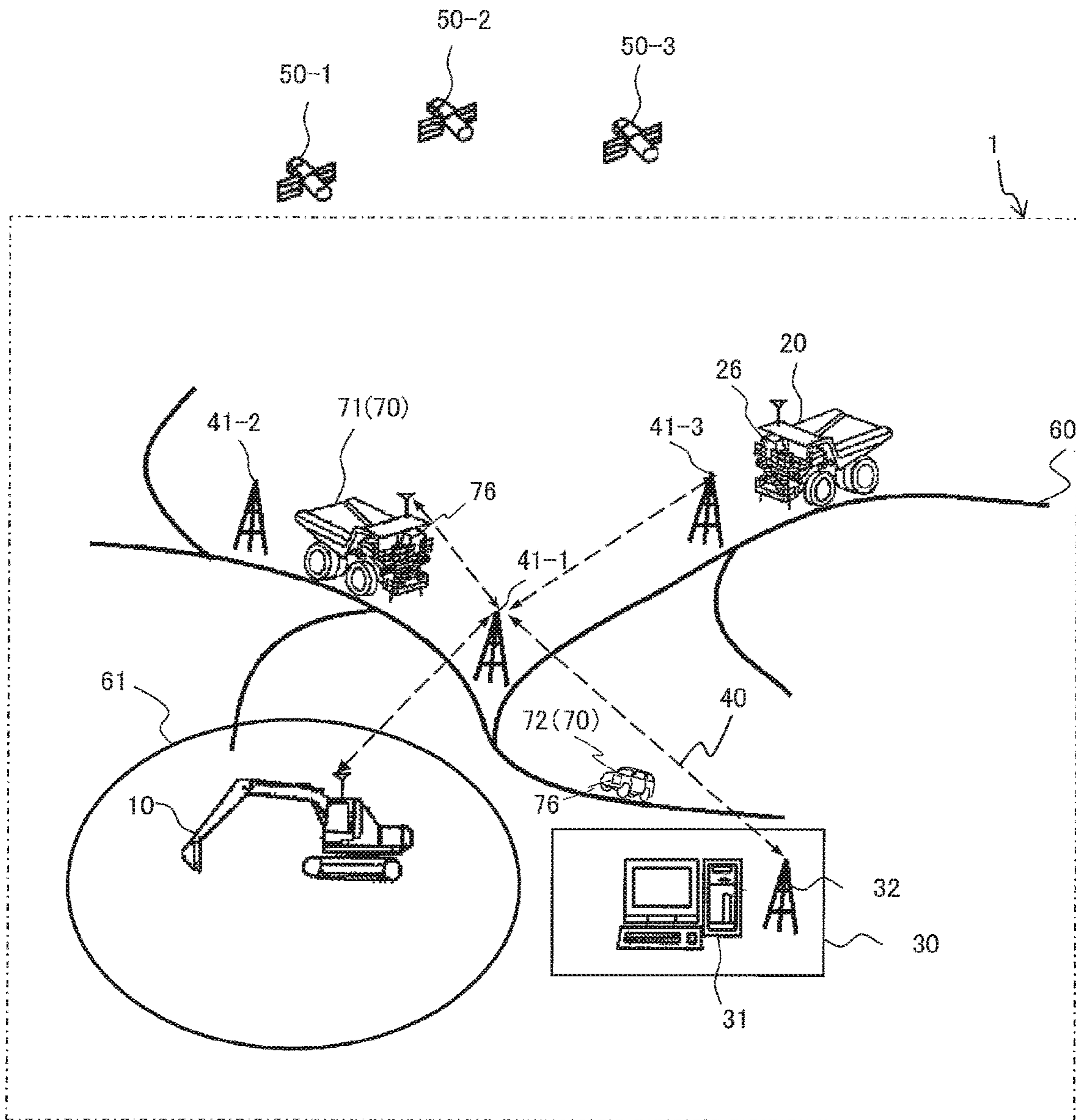


FIG. 2

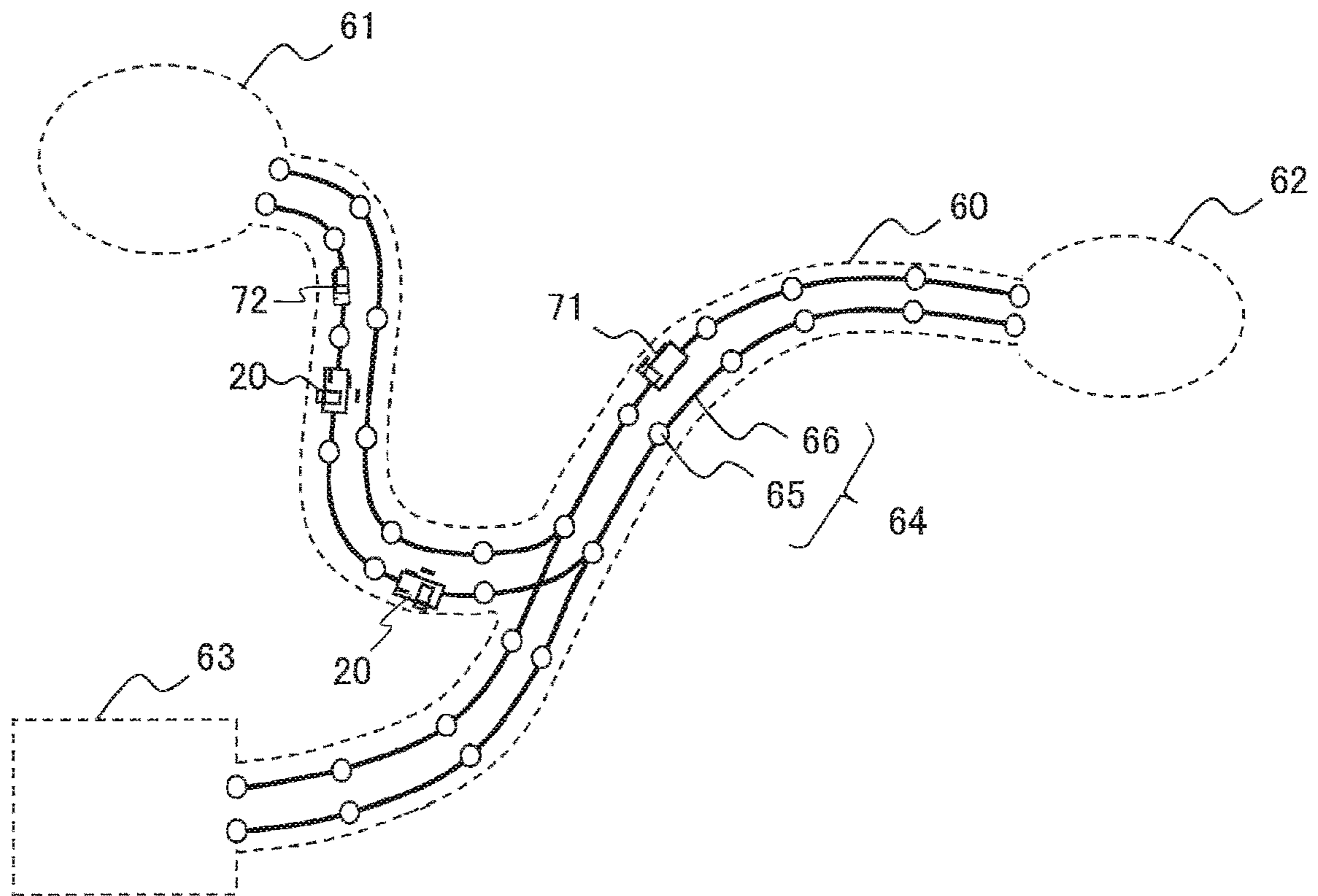


FIG. 3

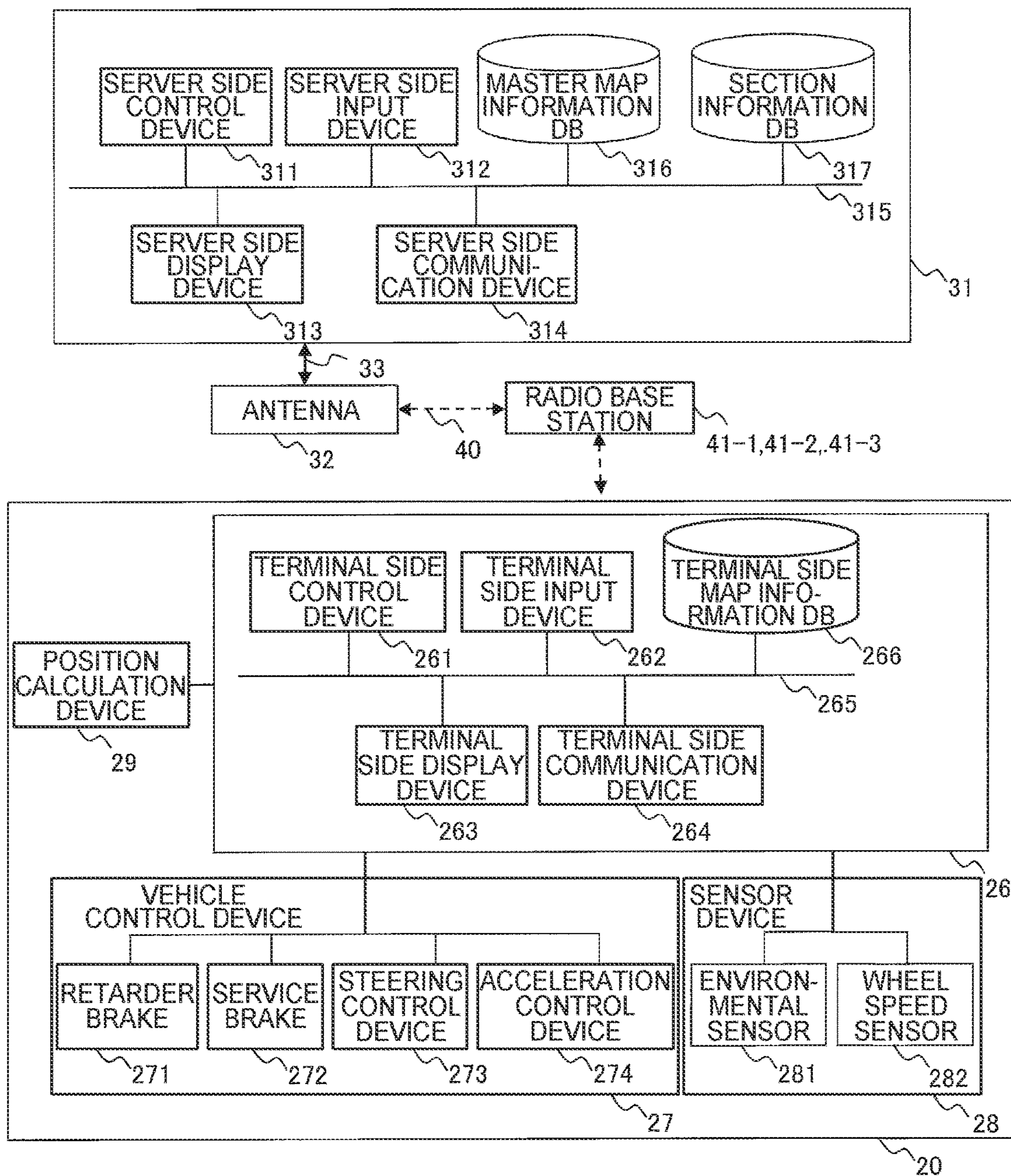


FIG. 4A

NODE ID	NODE COORDINATE
$N_{n-1}$	$x_{n-1}, y_{n-1}$
$N_n$	$x_n, y_n$
$N_{n+1}$	$x_{n+1}, y_{n+1}$
$N_{n+2}$	$x_{n+2}, y_{n+2}$
$N_{n+3}$	$x_{n+3}, y_{n+3}$

FIG. 4B

LINK ID	FORWARD NODE ID	BACKWARD NODE ID	SPEED LIMIT	CURVATURE
$L_{n-1}$	$N_{n-1}$	$N_n$	$v_{n-1}$	$c_{n-1}$
$L_n$	$N_n$	$N_{n+1}$	$v_n$	$c_n$
$L_{n+1}$	$N_{n+1}$	$N_{n+2}$	$v_{n+1}$	$c_{n+1}$
$L_{n+2}$	$N_{n+2}$	$N_{n+3}$	$v_{n+2}$	$c_{n+2}$
$L_{n+3}$	$N_{n+3}$	$N_{n+4}$	$v_{n+3}$	$c_{n+3}$

FIG. 5

501	502	503	504	505	506	507
VEHICLE ID	FORWARD BOUNDARY POINT	BACKWARD BOUNDARY POINT	DESTINATION	TRAVEL SPEED	TRAVEL DIRECTION	PRESENT POSITION
$D_1$	$N_{n-2}$	$N_n$	$P_1$	$VD_1$	F	$N_{n-1}$
$D_2$	$N_n$	$N_{n+2}$	$P_2$	$VD_2$	R	$N_{n+1}$
$D_3$	$N_{n+2}$	$N_{n+4}$	$P_3$	$VD_3$	F	$N_{n+3}$

FIG. 6

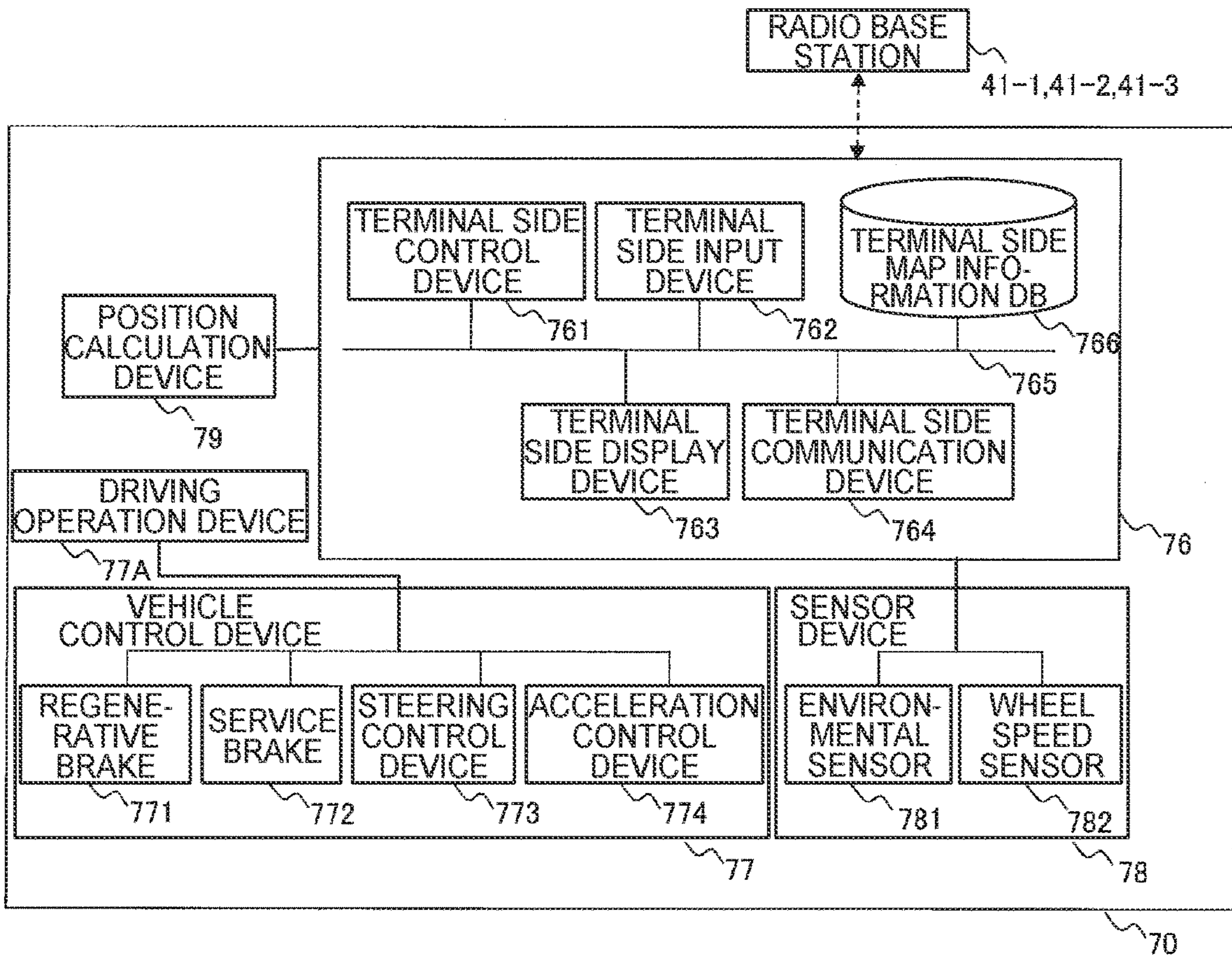
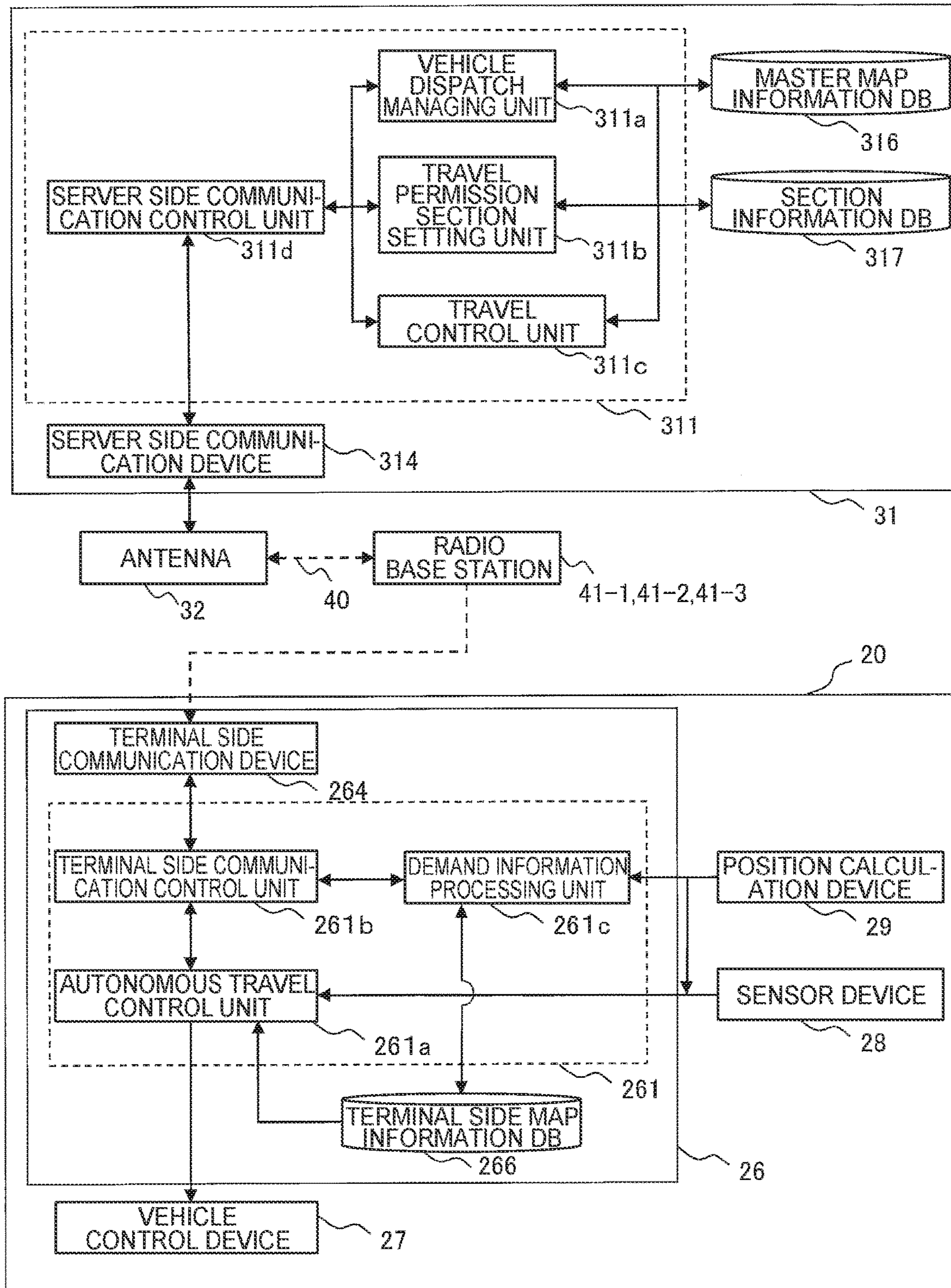


FIG. 7





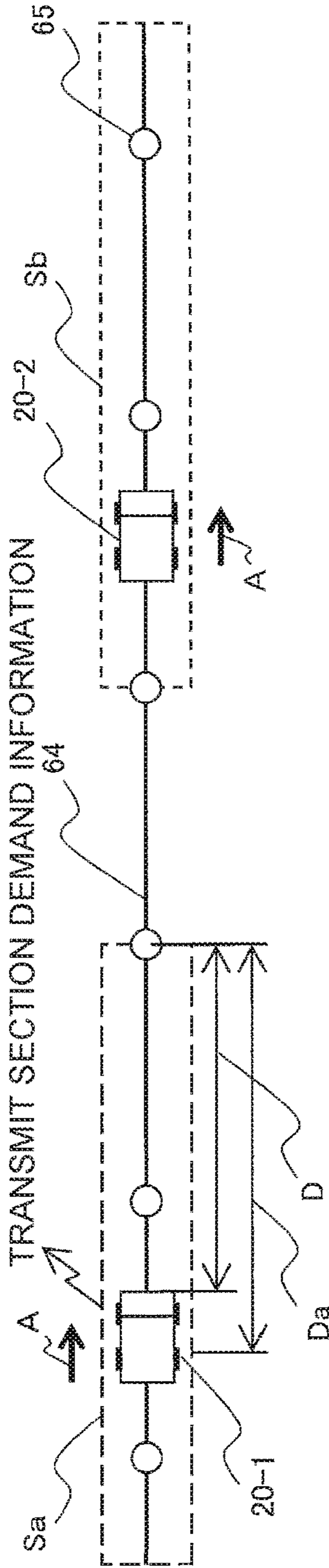


FIG. 8A

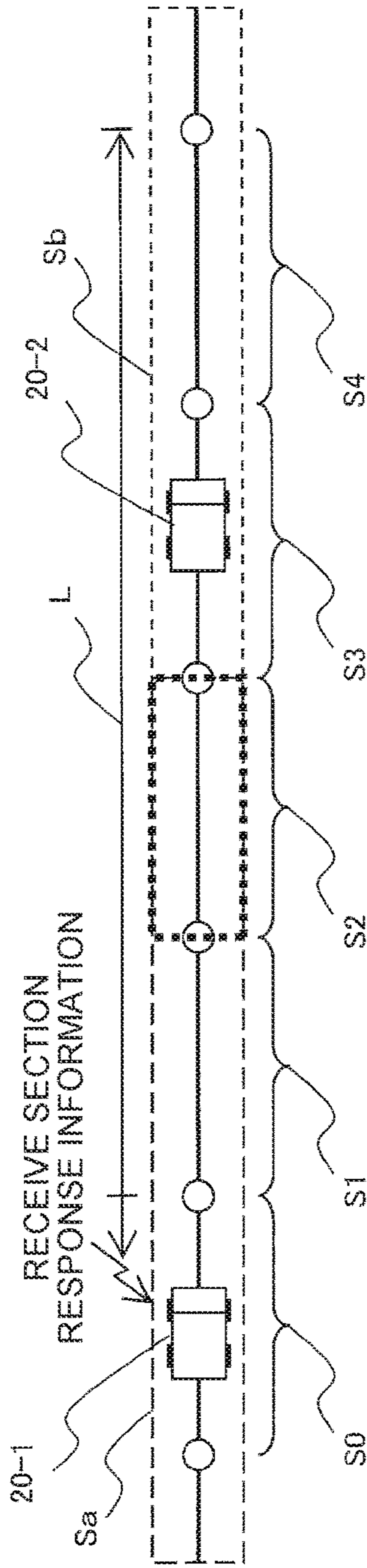


FIG. 8B

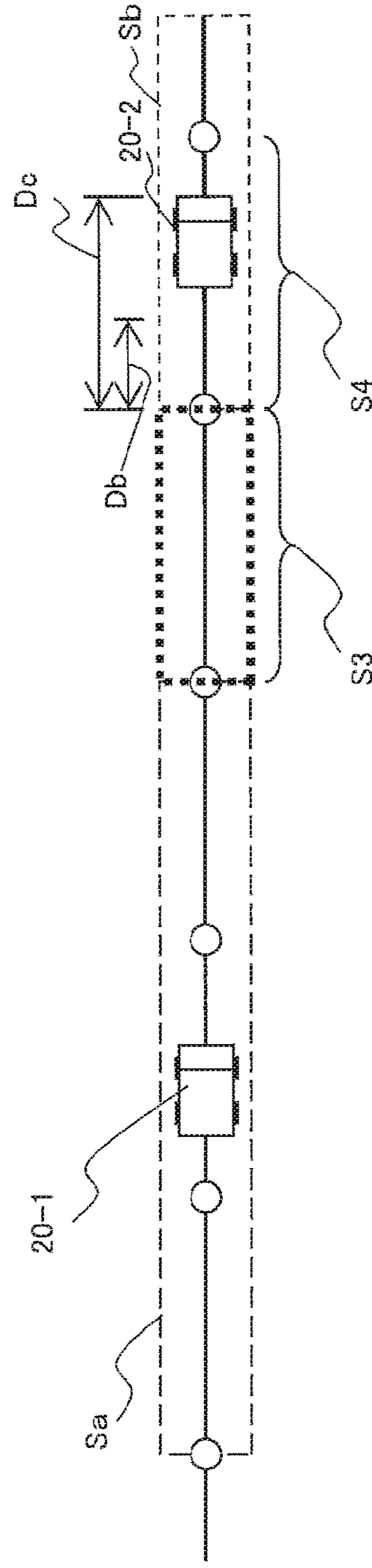


FIG. 8C

FIG. 9

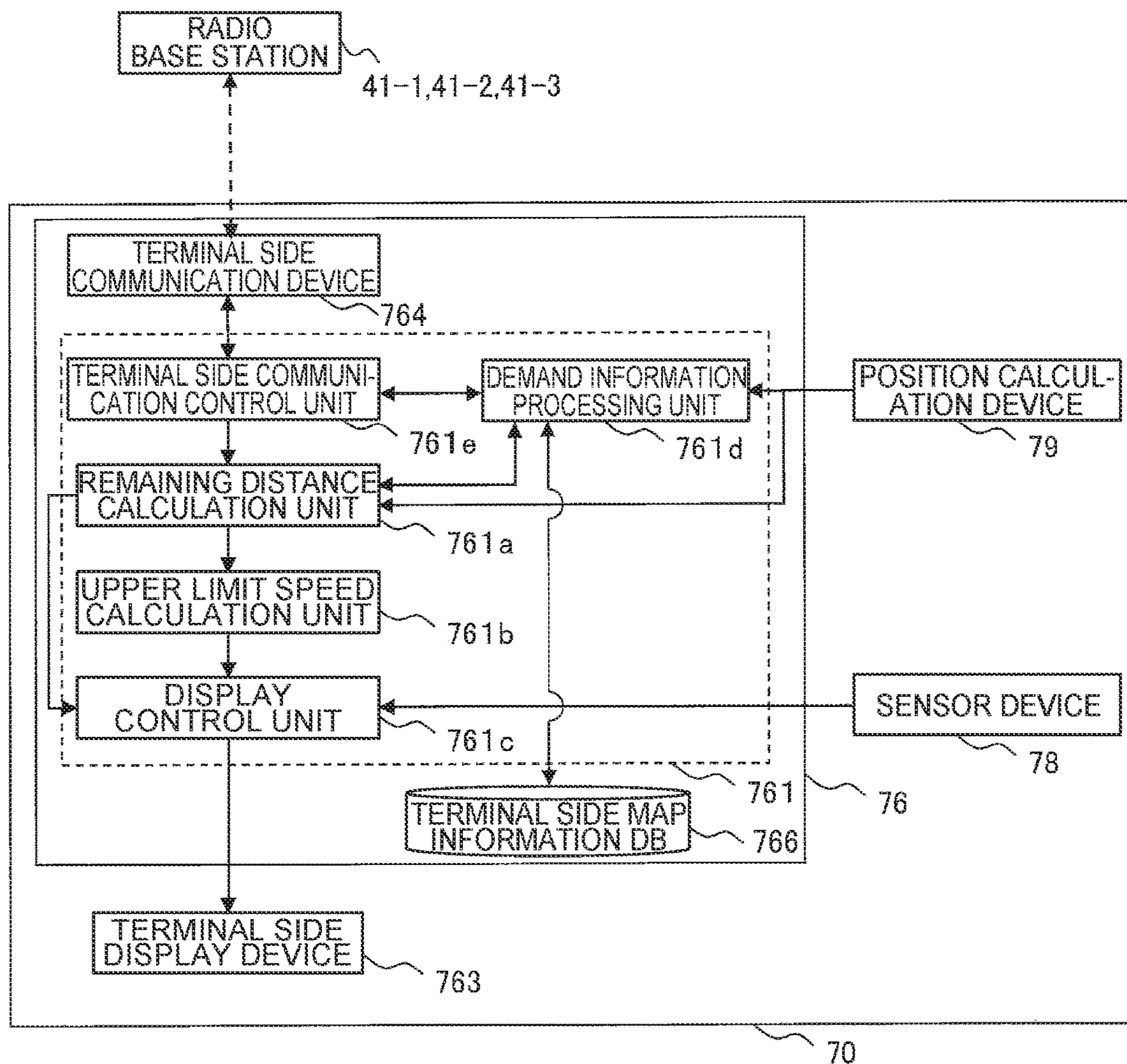


FIG. 10

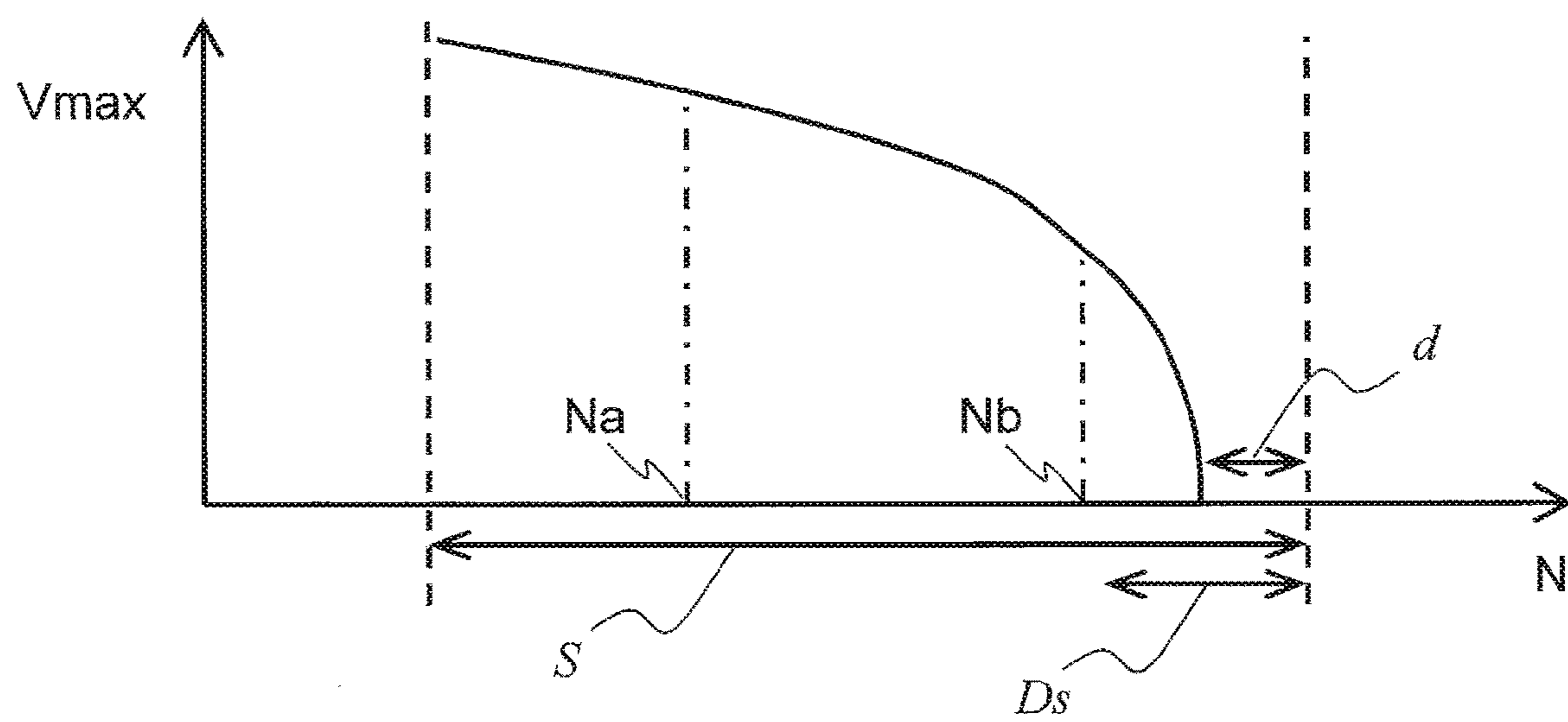


FIG. 11A

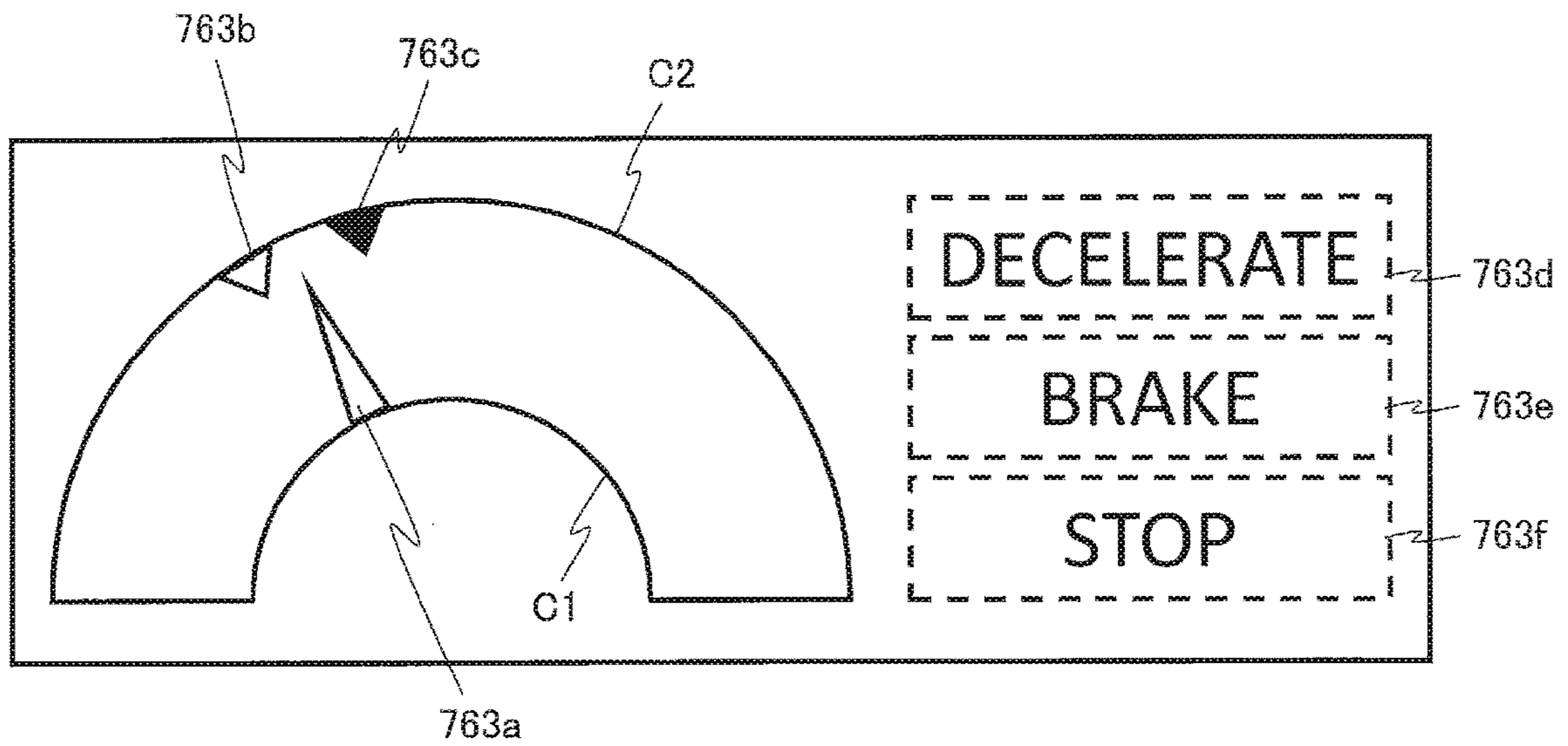


FIG. 11B

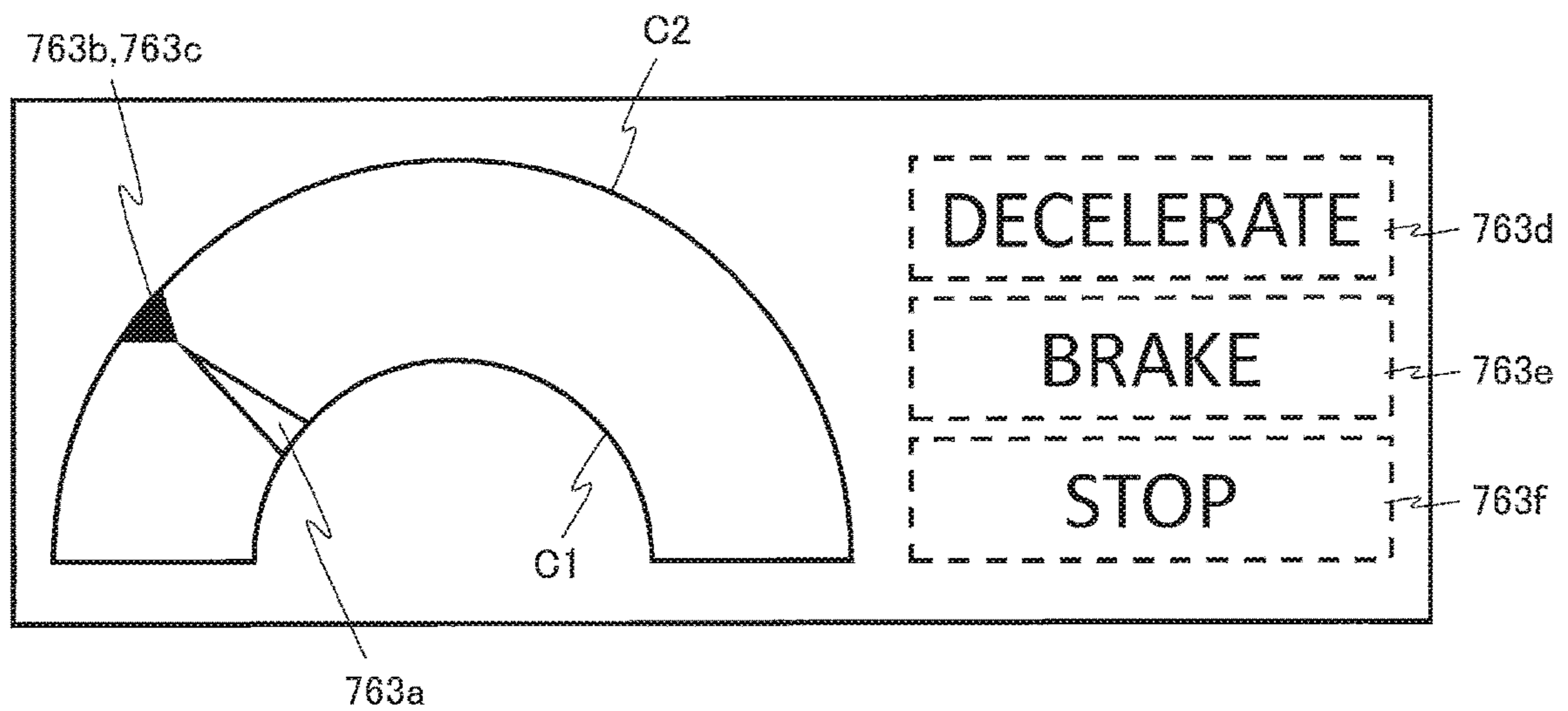


FIG. 12

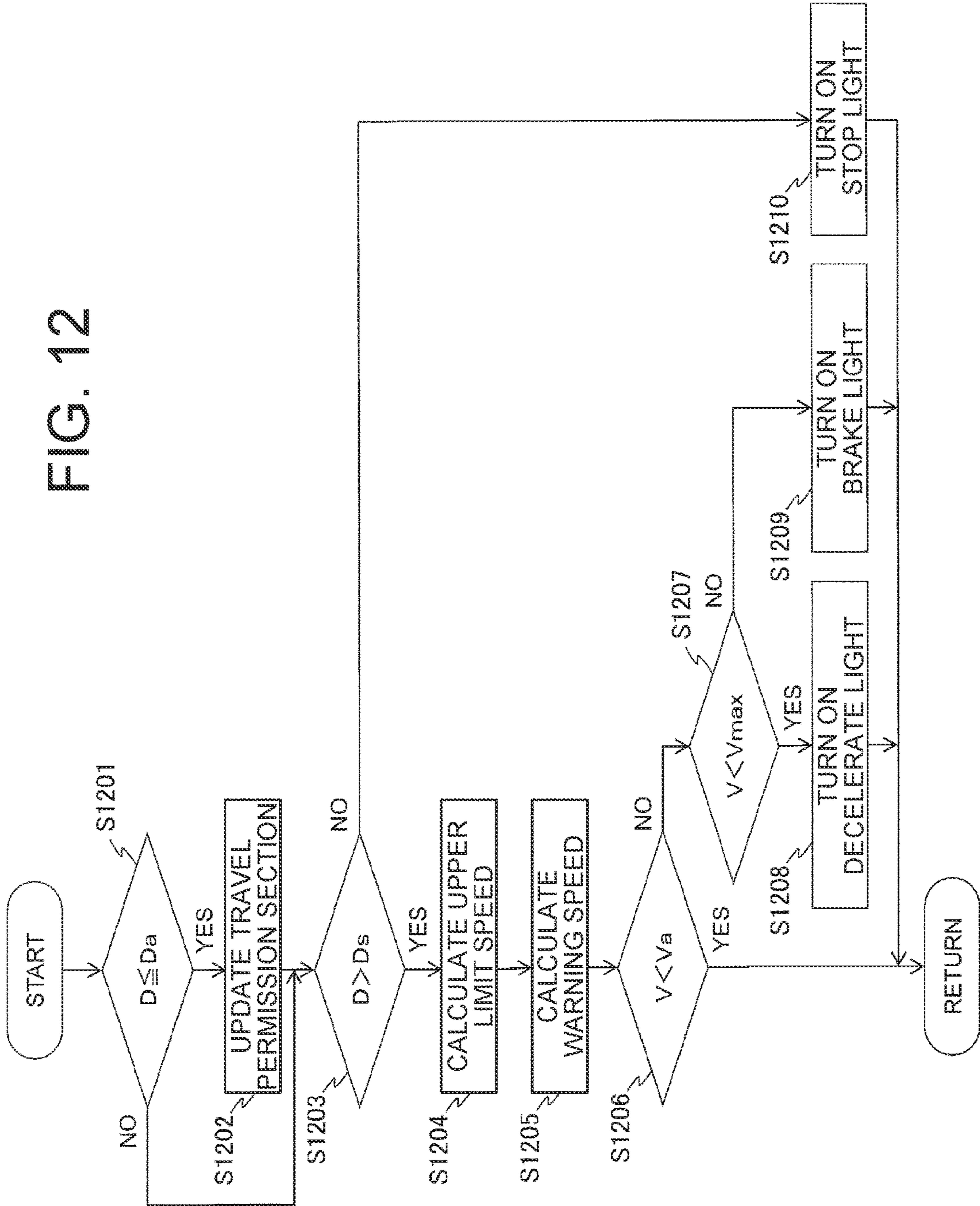


FIG. 13

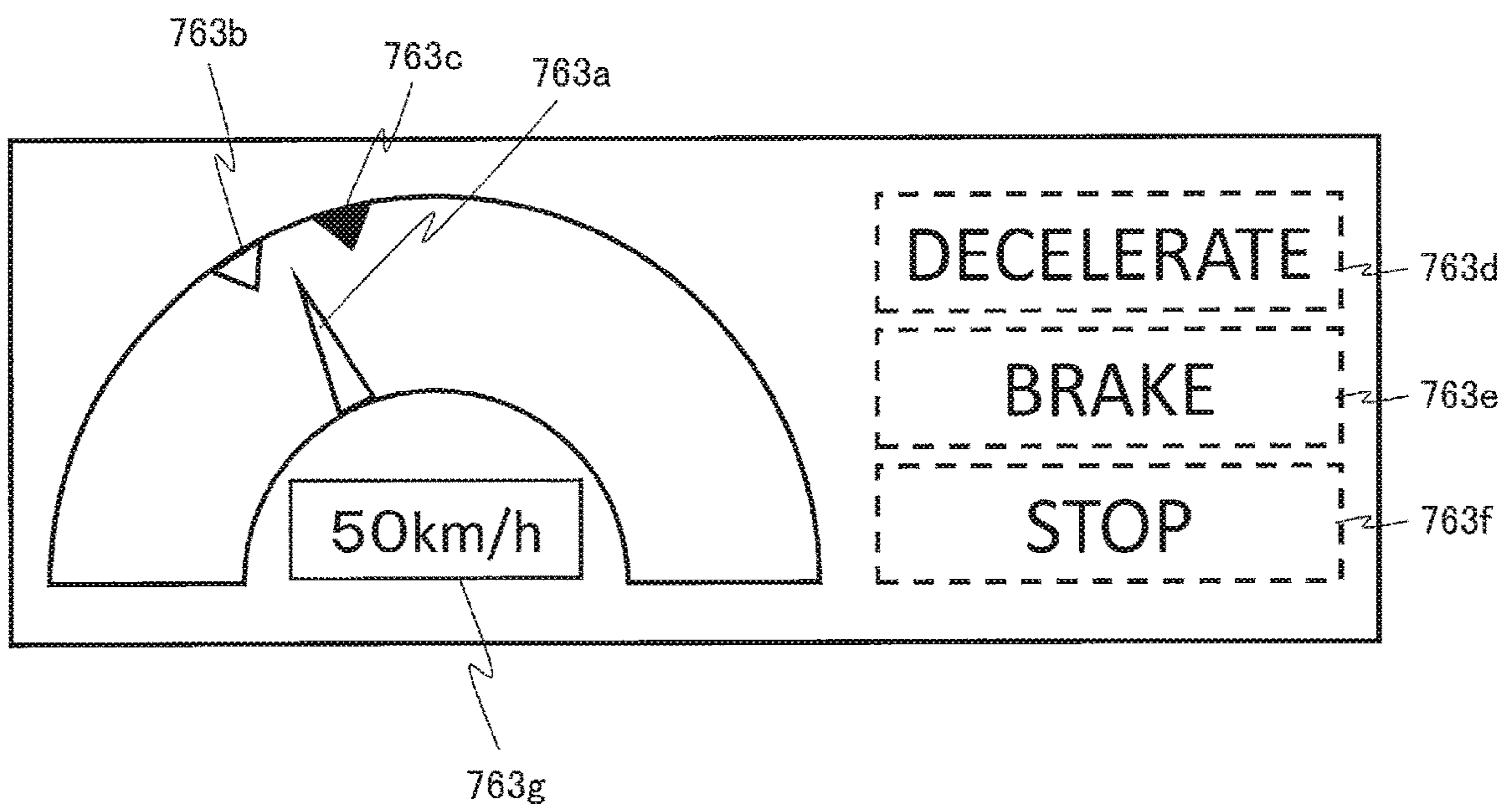
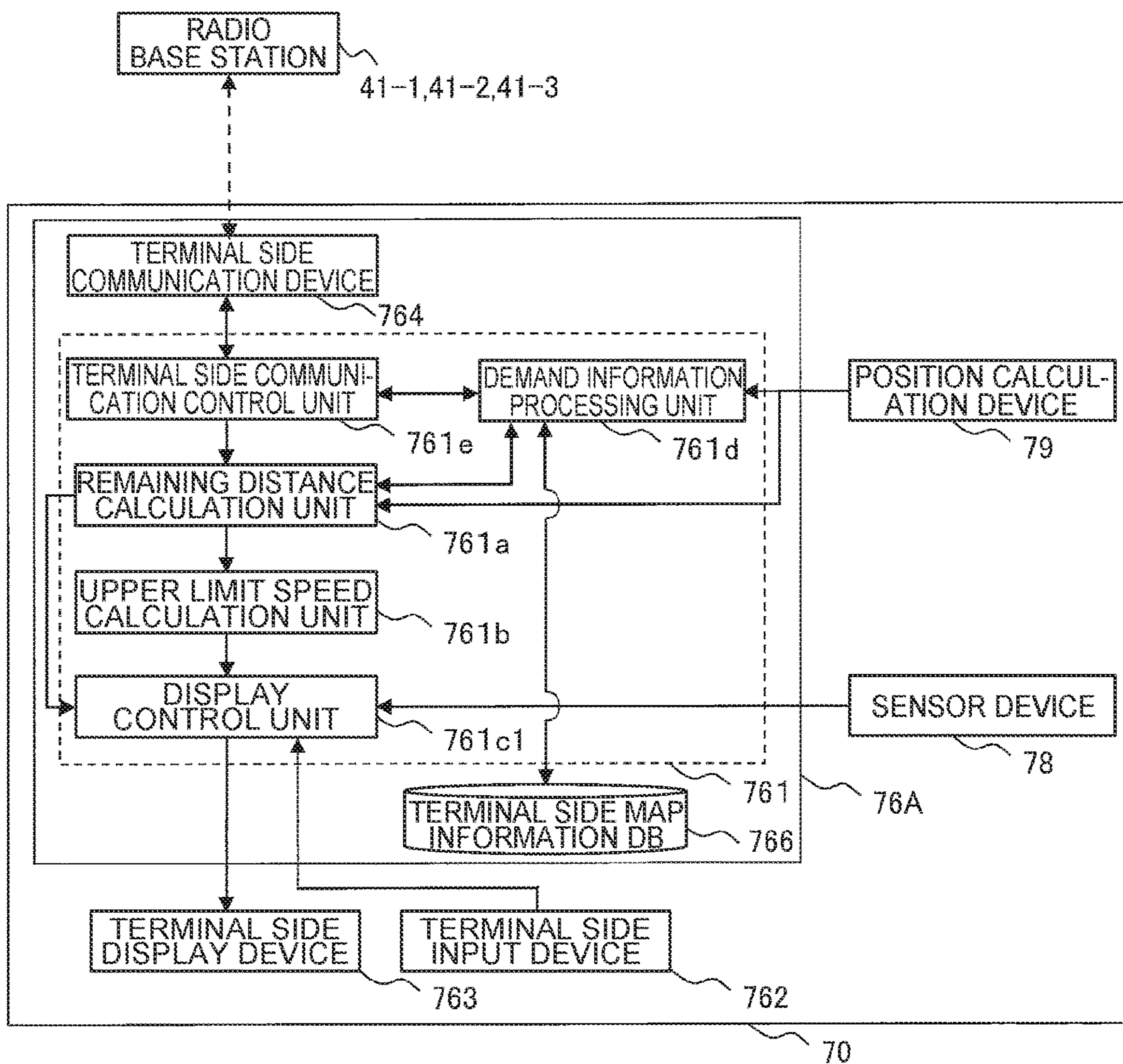


FIG. 14



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## ONBOARD TERMINAL DEVICE AND TRAFFIC CONTROL SYSTEM

### TECHNICAL FIELD

The present invention relates to an onboard terminal device and a traffic control system, and relates specifically to a technology of control for preventing interference between vehicles traveling in a mine.

### BACKGROUND ART

In an open pit mine and the like, when an unmanned vehicle such as a dump truck transporting excavated ore is made to autonomously travel, it is necessary to control manned vehicles such as a dozer and grader for maintaining a road, a motor sprinkler for preventing dust, a service car for a patrol, and so on and unmanned vehicles so as not to interfere with each other.

As one of prior arts for such purpose, a vehicle monitoring system is known, for example, which is configured of plural vehicles each provided with a vehicle position measuring device that measures the own vehicle position and a monitoring station that receives position data transmitted from each of these plural vehicles and transmits instruction data for instructing these plural vehicles of travel, stop and the like while monitoring the mutual positional relation of these plural vehicles based on the position data received (refer to Patent Literature 1).

### SUMMARY OF INVENTION

#### Technical Problem

According to the prior art disclosed in Patent Literature 1 described above, it is configured that the monitoring station constantly grasps the positional relation of each vehicle and conducts preset control so as to avoid interference of vehicles according to the positional relation of them. However, while a trouble occurs in the communication condition such that communication between each vehicle and the monitoring station is interrupted and so on, the monitoring station cannot recognize the mutual positional relation of respective vehicles, and it becomes difficult to conduct proper control. Accordingly, even when the possibility of interference of the vehicles is actually low, the monitoring station needs such action of stopping each vehicle and so on considering the safety of the work, and therefore drop of the work efficiency owing to the trouble of the communication condition has become a problem.

The present invention has been achieved in the circumstances of such prior art, and its object is to provide an onboard terminal device and a traffic control system that can suppress interference between vehicles and can improve the work efficiency even when a problem occurs in the communication condition.

#### Solution To Problem

In order to achieve the object described above, the present invention is an onboard terminal device that is connected to a traffic control server through a radio communication channel, the traffic control server conducting traffic control for avoiding interference between vehicles including an unmanned vehicle that travels autonomously in a mine, and is mounted on a manned vehicle that travels with a driver getting on including a travel instruction processing device

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that conducts processing for instructing the driver on travel of an own vehicle that is the manned vehicle with the driver getting on based on a travel permission section where a partial section of a travel route of the vehicle is assigned by the traffic control server as a section permitted for the vehicle to travel in which the travel instruction processing device includes a remaining distance calculation unit that calculates a travel permission remaining distance that shows a distance between a present position of the own vehicle to an end of the travel permission section along the travel route on the basis of the present position of the own vehicle acquired from a position acquiring device that is connected to the travel instruction processing device and the travel permission section, an upper limit speed calculation unit that calculates an upper limit speed of the own vehicle in the travel permission section on the basis of the travel permission remaining distance calculated by the remaining distance calculation unit, and an information presentation unit that causes an output device connected to the travel instruction processing device to output and present to the driver the upper limit speed calculated by the upper limit speed calculation unit and predetermined warning information corresponding to the upper limit speed.

#### Advantageous Effects Of Invention

According to the onboard terminal device and the traffic control system of the present invention, even when a problem occurs in the communication condition, interference of vehicles can be suppressed, and the working efficiency can be improved. Problems, configurations and effects other than the above will be clarified by explanation of embodiments below.

### BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a drawing showing a schematic configuration of a traffic control system related to a first embodiment of the present invention.

FIG. 2 is a drawing showing the detail of a transportation road shown in FIG. 1.

FIG. 3 is a drawing showing a hardware configuration of a control server and a configuration of a dump truck including a hardware configuration of a dump terminal device related to the first embodiment of the present invention.

FIG. 4 is a drawing showing a configuration of map information stored in a master map information DB shown in FIG. 3, FIG. 4A is a drawing showing a configuration of node information, and FIG. 4B is a drawing showing a configuration of link information.

FIG. 5 is a drawing showing a configuration of section information stored in a section information DB shown in FIG. 3.

FIG. 6 is a drawing showing a configuration of a manned vehicle including a hardware configuration of a manned vehicle terminal device related to the first embodiment of the present invention.

FIG. 7 is a function block diagram showing main functions of a control server and a dump terminal device shown in FIG. 3.

FIG. 8 is a drawing explaining a setting process for a travel permission section by a travel permission section setting unit shown in FIG. 7, FIG. 8A is a drawing showing a travel permission section set for each dump truck, FIG. 8B is a drawing showing a travel permission section newly set for a dump truck to follow, and FIG. 8C is a drawing showing an open section.



FIG. 9 is a function block diagram showing main functions of a manned vehicle terminal device shown in FIG. 6.

FIG. 10 is a drawing showing the relationship between a position N of a manned vehicle traveling a travel permission section S and an upper limit speed Vmax.

FIG. 11 is a drawing explaining a configuration of a display screen of a terminal side display device shown in FIG. 9, FIG. 11A is a drawing showing a display example when a manned vehicle travels at a position Na of FIG. 10, and FIG. 11B is a drawing showing a display example when the manned vehicle travels at a position Nb of FIG. 10.

FIG. 12 is a flowchart showing a flow of processing motions of a manned vehicle terminal device related to the first embodiment of the present invention.

FIG. 13 is a drawing showing a configuration of a display screen of a terminal side display device related to a second embodiment of the present invention.

FIG. 14 is a function block diagram showing main functions of a manned vehicle terminal device related to the second embodiment of the present invention.

### DESCRIPTION OF EMBODIMENTS

Below, embodiments of an onboard terminal device and a traffic control system related to the present invention will be explained based on the drawings.

Below, the embodiments of the present invention will be explained in detail based on the drawings. Also, in all drawings for explaining the embodiments, a member having a same function will be marked with a same or related reference sign, and repeated explanation thereof will be omitted. Further, in the embodiments below, explanation of a same or similar portion will not be basically repeated unless particularly necessary.

#### First Embodiment

A first embodiment of the present invention relates to a traffic control system that connects a dump truck (corresponding to an unmanned vehicle), a manned vehicle (inclusive of a case a driver gets on an unmanned vehicle), and a traffic control server (will be hereinafter abbreviated as "control server" for convenience) by a radio communication channel, the dump truck transporting soil, ore, and the like loaded by a loading machine such as a shovel and wheel loader in a mine and traveling autonomously without a driver getting on, the manned vehicle being such as a dozer, grader, motor sprinkler, and a service car traveling with a driver getting on, the traffic control server conducting traffic control for avoiding interference of these dump truck and manned vehicle, and is featured particularly in providing an instruction to a driver getting on a manned vehicle on travel of the own vehicle that is the manned vehicle with the driver oneself getting on. Below, a traffic control system related to the first embodiment of the present invention will be explained referring to the drawings.

First, a schematic configuration of a traffic control system related to the first embodiment of the present invention will be explained in detail referring to FIG. 1.

As shown in FIG. 1, a traffic control system 1 related to the first embodiment of the present invention is configured by mutual communication connection with respect to a shovel 10, a dump truck 20 (corresponding to an unmanned vehicle), a manned vehicle 70, and a control server 31 through a radio communication channel 40, the shovel 10 conducting loading work of soil, ore, and the like at a loading station 61 as a working station including a quarry

and a loading station of a mine and the like, the dump truck 20 being an autonomous travel vehicle for transporting a load of the soil, ore, and the like loaded by the shovel 10, the manned vehicle 70 being a dump truck 71, a dozer (not illustrated), a motor sprinkler (not illustrated), a service car 72, and the like, the dump truck 71 being similar to the dump truck 20 but another vehicle a driver gets on, the control server 31 being installed in a control center 30 located in the vicinity of or remote from the quarry.

The dump truck 20 reciprocates between the loading station 61 and soil dumping stations 62, 63 (refer to FIG. 2) along a transportation road 60 that is preset within the mine, and transports a load.

Plural radio base stations 41-1, 41-2, 41-3 are installed within the mine. Also, a radio wave of radio communication is transmitted and received through these radio base stations 41-1, 41-2, 41-3.

The shovel 10, the dump truck 20, and the manned vehicle 70 include a position calculation device (illustration thereof is omitted in FIG. 1) such as a GPS (Global Positioning System) for receiving a positioning radio wave from at least 3 navigation satellites 50-1, 50-2, 50-3 and calculating the position of the own vehicle. In other words, these navigation satellites 50-1, 50-2, 50-3 and the position calculation device function as a position acquiring device acquiring the present position of the vehicle. In fact, the dump truck 20 and the manned vehicle 70 are present by a plurality, and each of them communicates with the control server 31 wirelessly.

The dump truck 20 mounts an onboard terminal device (will be hereinafter abbreviated as "dump terminal device" for convenience) 26 for conducting autonomous travel according to an instruction from the control server 31.

The manned vehicle 70 mounts an onboard terminal device (will be hereinafter abbreviated as "manned vehicle terminal device" for convenience) 76 for receiving an instruction from the control server 31 so as not to interfere with the other vehicle 20 and giving an instruction on travel of the own vehicle to the driver. Further, the manned vehicle terminal device 76 may be mounted also on the shovel 10 although illustration thereof is omitted.

The control server 31 is connected to an antenna 32 that is for connection with the radio communication channel 40. Also, the control server 31 communicates with each of the dump terminal device 26 and the manned vehicle terminal device 76 through the antenna 32 and the radio base stations 41-1, 41-2, 41-3.

FIG. 2 is a drawing showing the detail of the transportation road 60 of FIG. 1, and shows a configuration example of an open pit mine site where the dump truck 20 and the manned vehicle 70 travel. The transportation road 60 connects the loading station 61 with the soil dumping station 62 and the soil dumping station 63. The dump truck 20 loads surface soil, ore and the like at the loading station 61, travels along the transportation road 60, and transports the surface soil, ore and the like to the soil dumping station 62 and the soil dumping station 63.

The loading station 61 is a work station for loading the surface soil, ore and the like excavated by the shovel 10 to the dump truck 20.

The soil dumping station 62 is a work station where the surface soil and the like transported from the excavation site by the dump truck 20 are dumped and are spread in a layered form or a radial form.

The soil dumping station 63 is a work station where a crusher (not illustrated) and the like for crushing the ore are installed. The ore crushed by the crusher is transported by a

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belt conveyor and the like to a load out site by a railroad freight car or a processing facility and the like.

In each of the work stations described above, an operator gets on a dozer and displaces spilt soil to a position not impeding travel of the dump truck **20**, gets on a measuring car that measures positional information, travels within the work station, and measures the positional information, and so on.

On the transportation road **60**, two travel routes **64** with different travel direction of the dump truck **20** are arranged. Respective travel routes **64** constitute an inbound traffic lane and an outbound traffic lane. Respective travel routes **64** connect the entrance or exit of respective work stations to each other. The travel route of each work station is formed from time to time according to movement of the vehicle stop position of the dump truck **20** within the work station, for example, movement of the loading point and movement of the soil dumping point.

The travel route **64** is given as coordinate values set on a map. The dump truck **20** travels in an unmanned state along the travel route **64** by controlling acceleration and deceleration as well as steering while comparing the own position determined by the position sensor (GPS) and the coordinate values of the travel route **64**. With respect to information of the travel route **64** and nodes **65**, same information is stored as the map data of the control server **31** and the map data of the dump truck **20**. The control server **31** controls travel so as to avoid interference of the dump trucks **20** to each other by granting/cancelling the travel permission for each travel section that is specified to be a portion between the nodes **65** and notifying the dump truck **20** of the information. The portion between neighboring nodes **65** is called a link **66**.

Next, a hardware configuration of the control server **31** and a configuration of the dump truck **20** including a hardware configuration of the dump terminal device **26** related to the first embodiment of the present invention will be explained in detail referring to FIG. **3**.

As shown in FIG. **3**, the control server **31** is configured so as to include a server side control device **311**, a server side input device **312**, a server side display device **313**, a server side communication device **314**, a communication bus **315**, a master map information database (database will be hereinafter abbreviated as "DB" for convenience) **316**, and a travel permission section information DB (will be hereinafter abbreviated as "section information DB" for convenience) **317**.

The server side control device **311** is for controlling the motion of each constituent element of the control server **31**, and is configured using a calculation/control device such as a CPU (Central Processing Unit), a storage device such as a ROM (Read Only Memory) and an HDD (Hard Disk Drive) which stores programs executed by the control server **31**, and hardware including a RAM (Random Access Memory) which becomes a work region when the CPU executes the programs. The function configuration of the programs executed in the control server **31** will be described below referring to FIG. **7**. Further, the server side control device **311** may be configured also using an integrated circuit (ASIC: application specific integrated circuit) for achieving functions executed by the control server **31**.

The server side input device **312** is configured by an input device such as a mouse, keyboard and the like, and functions as a user interface when an operator executes an operation for inputting information required, for example, for controlling autonomous travel of the dump truck **20** and instructing travel of the manned vehicle **70**.

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The server side display device **313** is configured by a liquid crystal monitor and the like, and functions as an interface that displays and provides information to the operator.

The server side communication device **314** is configured by a device for connecting communication to a wire communication channel **33** and the radio communication channel **40**. The server side communication device **314** receives section demand information described below from the dump truck **20** and the manned vehicle **70**, and transmits section response information and non-permission response information described below to the dump truck **20** and the manned vehicle **70**.

The communication bus **315** electrically connects respective constituent elements to each other.

The master map information DB **316** is configured using a storage device such as an HDD that fixedly stores information, and stores the map information that is defined by the position information (coordinate value) of each node **65** on the transportation road **60** and the link **66** connecting respective nodes **65**. Further, the master map information DB **316** may also include topographic information of the mine, and an absolute coordinate (three-dimensional actual coordinate calculated on the basis of the positioning radio wave) of each node **65**. To each of the nodes **65** and the links **66**, position identification information (will be hereinafter referred to as "node ID" and "link ID" for convenience) that identifies the node **65** and the link **66** uniquely is given.

The map information includes node information **400** that correlates a node ID **401** and a node coordinate **402** as shown in FIG. **4A**, for example, and link information **420** that correlates a link ID **421** and attribute information of the link such as a node (forward node ID) **422** at the front end of the link, a node (backward node ID) **423** at the rear end, a speed limit **424**, a curvature **425** of the transportation road **60**, and the like as shown in FIG. **4B**. Further, the map information may also include the direction of the dump truck **20** traveling on the travel route **64**.

The section information DB **317** is configured using a storage device such as an HDD that fixedly stores information, and stores the present position of the dump truck **20** and the manned vehicle **70** and the section information including the travel permission section assigned to the dump truck **20** and the manned vehicle **70**. As shown in FIG. **5**, for example, this section information is configured so as to correlate a vehicle ID **501** identifying each vehicle uniquely to a forward boundary point (shown by a node ID, same with respect to the backward boundary point also) **502** of a travel permission section set for the vehicle, a backward boundary point **503**, a destination **504** showing the final destination coordinate set for each vehicle at present, an actual travel speed **505** of the vehicle, a travel direction **506** showing whether the vehicle is traveling forward or rearward, and a present position **507** of the vehicle notified from each vehicle regularly or as needed.

Each of the master map information DB **316** and the section information DB **317** having such configuration may include only a storage unit storing the map information and the section information and the server side control device **311** may execute updating/retrieving process of the DB, or otherwise an engine executing updating/retrieving process of the information may be mounted on each DB.

In contrast, the dump truck **20** is an electrically driven dump truck, and includes a vehicle control device **27** that receives an instruction from the dump terminal device **26** and controls acceleration and deceleration as well as steer-

ing, a sensor device **28**, and a position calculation device **29** in addition to the dump terminal device **26** as shown in FIG. **3**.

The dump terminal device **26** is configured so as to include a terminal side control device **261**, a terminal side input device **262**, a terminal side display device **263**, a terminal side communication device **264**, a communication bus **265**, and a terminal side map information DB **266**.

Since each of the terminal side control device **261**, the terminal side input device **262**, the terminal side display device **263**, the terminal side communication device **264**, the communication bus **265**, and the terminal side map information DB **266** has a same configuration to that of each of the server side control device **311**, the server side input device **312**, the server side display device **313**, the server side communication device **314**, the communication bus **315**, and the master map information DB **316**, duplicated explanation thereof will be omitted. The terminal side map information DB **266** described above stores map information same to that stored in the master map information DB **316**.

The vehicle control device **27** includes a regenerative brake **271**, a mechanical brake **272**, a steering control device **273**, and an acceleration control device **274**. The vehicle control device **27** is electrically connected to the dump terminal device **26**, and makes the dump truck **20** autonomously travel according to an instruction from the control server **31**.

The sensor device **28** includes an environmental sensor **281** such as a millimeter wave radar, a front camera, and the like, for example, for detecting an obstacle at a forward position in the travel direction (advancing direction) of the dump truck **20** and a wheel speed sensor **282** that is arranged in the vicinity of a front wheel of the dump truck **20** and detects the rotation speed of the front wheel. Since the wheel speed sensor **282** detects the rotation speed of a driven wheel of the dump truck **20**, the wheel speed sensor **282** can be deemed to detect the speed of the vehicle.

The position calculation device **29** calculates the present position of the own vehicle on the basis of the positioning radio wave from the navigation satellites **50-1**, **50-2**, **50-3** (refer to FIG. **1**). The present position of the own vehicle calculated is transmitted from the dump terminal device **26** to the control server **31**.

Next, a configuration of the manned vehicle **70** including a hardware configuration of the manned vehicle terminal device **76** related to the first embodiment of the present invention will be explained in detail referring to FIG. **6**.

Similarly to the dump truck **20**, the manned vehicle **70** includes a vehicle control device **77** that controls acceleration and deceleration as well as steering by operation of a driver, a sensor device **78**, and a position calculation device **79** in addition to the manned vehicle terminal device **76** as shown in FIG. **6**.

Similarly to the dump terminal device **26**, the manned vehicle terminal device **76** also includes a terminal side control device **761**, a terminal side input device **762**, a terminal side display device (output device) **763**, a terminal side communication device **764**, a communication bus **765**, and a terminal side map information DB **766**. Since these respective constituent elements have a configuration similar to that of the dump terminal device **26**, duplicated explanation thereof will be omitted.

The vehicle control device **77** includes a regenerative brake **771**, a mechanical brake **772**, a steering control device **773**, and an acceleration control device **774**. The vehicle control device **77** is electrically connected to a driving operation device **77A** such as an acceleration pedal accel-

erating the manned vehicle **70** and a deceleration pedal decelerating the manned vehicle **70**, and makes the own vehicle travel through the vehicle control device **77** by that the driver operates the driving operation device **77A** while properly confirming the display screen of the terminal side display device **763**.

The sensor device **78** includes an environmental sensor **781** and a wheel speed sensor **782**. Since each constituent element of the sensor device **78** and the position calculation device **79** is similar to that of the dump truck **20**, duplicated explanation thereof will be omitted.

Next, a concrete configuration showing the function of the control server **31** and the dump terminal device **26** related to the first embodiment of the present invention will be explained in detail referring to FIG. **7** and FIG. **8**.

As shown in FIG. **7**, the server side control device **311** of the control server **31** includes a vehicle dispatch managing unit **311a**, a travel permission section setting unit **311b**, a travel control unit **311c**, and a server side communication control unit **311d**.

The vehicle dispatch managing unit **311a** sets a destination of the dump truck **20** and the manned vehicle **70**, refers to the map information stored in the master map information DB **316**, and determines the travel route **64** from the present position to the destination.

The travel permission section setting unit **311b** refers to the map information stored in the master map information DB **316** with respect to the dump truck **20** and the manned vehicle **70**, sets a partial section of the travel route **64** on the transportation road **60** as a travel permission section for allowing the dump truck **20** to travel, and creates section information that shows the position of the travel permission section.

The travel permission section setting unit **311b** overwrites and updates the section information stored in the section information DB **317** with newly created section information. As described above, the section information includes a node ID of the forward boundary point **502** which is a node of the foremost end of the travel permission section and a node ID of the backward boundary point **503** which is a node of the rearmost end. Since the section information includes the travel permission section set for the dump truck **20** and the manned vehicle **70**, when the section information is referred to, in which travel permission section the dump truck **20** and the manned vehicle **70** exist and, by referring to the map information, the travel direction of the dump truck **20** and the manned vehicle **70** are grasped.

When information demanding setting of new travel permission section (will be hereinafter referred to as "section demand information" for convenience) from the dump terminal device **26**, the travel permission section setting unit **311b** executes a setting process for the travel permission section responding to it. When a new travel permission section setting has been set, the travel permission section setting unit **311b** creates section response information that shows the new travel permission section. When the section response information could not be created, the travel permission section setting unit **311b** creates non-permission response information that shows non-permission of travel.

The travel control unit **311c** creates control information that shows the travel speed of the dump truck **20** and the manned vehicle **70**, and travel or start permission, display stop, oil feed timing, and the like of the dump truck **20** and the manned vehicle **70**.

The server side communication control unit **311d** executes control of radio communication between the dump terminal device **26** and the manned vehicle terminal device **76**. The

server side communication control unit **311d** executes control for transmitting and receiving the section demand information, the section response information, the non-permission response information, and the control information between the dump terminal device **26** and the manned vehicle terminal device **76**.

Next, the dump terminal device **26** will be explained. The terminal side control device **261** of the dump terminal device **26** includes an autonomous travel control unit **261a**, a terminal side communication control unit **261b**, and a demand information processing unit **261c**.

The autonomous travel control unit **261a** executes control for acquiring the present position of the own vehicle from the position calculation device **29**, referring to the map information of the terminal side map information DB **266**, and making the own vehicle travel according to the travel permission section included in the section information with respect to the vehicle control device **27**. Also, the autonomous travel control unit **261a** determines presence/absence of a forward obstacle on the basis of the detection result of the sensor device **28**, also determines presence/absence of the avoiding motion for interference and collision against the obstacle, and, if necessary, executes control for a braking motion.

The terminal side communication control unit **261b** executes control of radio communication conducted between the control server **31**. The terminal side communication control unit **261b** transmits the section demand information, and receives the section response information, the non-permission response information, and the control information.

The demand information processing unit **261c** determines whether the dump truck **20** has reached a point for transmitting the section demand information on the basis of the map information stored in the terminal side map information DB **266** and the present position calculated by the position calculation device **29**. When the dump truck **20** reaches the demand point, the demand information processing unit **261c** creates section demand information, and transmits the section demand information to the control server **31** through the terminal side communication control unit **261b**.

The vehicle dispatch managing unit **311a**, the travel permission section setting unit **311b**, the travel control unit **311c**, and the server side communication control unit **311d** in the control server **31** configured as described above are achieved by that the programs achieving the function of them are executed by the server side control device **311** (hardware) shown in FIG. **3**.

In a similar manner, the autonomous travel control unit **261a**, the terminal side communication control unit **261b**, and the demand information processing unit **261c** in the dump terminal device **26** configured as described above are achieved by that the programs achieving the function of them are executed by that the programs achieving the function of them are executed by the terminal side control device **261** (hardware) shown in FIG. **3**.

Here, the setting process for the travel permission section by the travel permission section setting unit **311b** in the control server **31** will be explained in detail referring to FIG. **8**.

Dump trucks **20-1**, **20-2** shown in FIG. **8A** are dump trucks during traveling toward the arrow A direction. A section Sa is a travel permission section that is set for the dump truck **20-1**. A section Sb is a travel permission section that is set for the dump truck **20-2**. A distance D is a travel permission remaining distance showing the distance along the travel route **64** from the present position of the dump

truck **20** to the forward boundary point (distal end) of the travel permission section Sa. A distance Da is a travel permission demand start distance for starting transmission of the section demand information. In explanation below, when the trucks **20-1** and **20-2** are not discriminated, the dump truck is written as the dump truck **20**.

The travel permission demand start distance Da is a distance longer than a distance the dump truck **20** can stop (will be hereinafter referred to as “stoppable distance”, and will be expressed as UVSL), and is defined, for example, as a distance adding a predetermined offset distance m to UVSL. In this case, the travel permission demand start distance Da can be expressed by an expression (1) below. Also, UVSL is calculated on the basis of a distance the dump truck **20** can stop from the present speed, and can be expressed by an expression (2) below, for example.

[Math. 1]

$$Da = UVSL + m \quad (1)$$

where m: margin

[Math. 2]

$$UVSL = c_u \frac{M_u v_u^2}{2f_u} \quad (2)$$

where

$c_u$ : factor determined for obtaining stoppable distance of unmanned dump truck

$M_u$ : mass including load of unmanned dump truck

$v_u$ : present speed of unmanned dump truck

$f_u$ : braking force of unmanned dump truck

The value of the predetermined offset distance m is set considering the time taken for radio communication, the degree of occurrence of the failure of radio communication, and so on, for example. The speed  $v_u$  of the dump truck **20** may be the present speed of the dump truck **20** measured from the rotation speed and the like of the wheel, that is, the detection value of the wheel speed sensor **282**, and may use a maximum allowable speed that has been set in the map information stored in the master map information DB **316** and the terminal side map information DB **266** with respect to the present travel position of the dump truck **20**.

When the travel permission remaining distance D of the dump truck **20** becomes equal to or less than the travel permission demand start distance Da, the dump truck **20** transmits the section demand information to the control server **31**. The section demand information includes information of the present position of the dump truck **20**.

When the section demand information is received from the dump truck **20-1**, the travel permission section setting unit **311b** determines a section (corresponding to the travel route **64** between neighboring nodes **65**) where the dump truck **20-1** exists on the basis of the information of the present position included in the section demand information having been transmitted. Then, the travel permission section setting unit **311b** grants a travel permission with respect to a section that becomes equal to or longer than the travel permission granted length from the distal end of the section where the dump truck **20-1** exists toward the front in the advancing direction of the dump truck **20-1**. However, when there is a section where a permission has been granted to other vehicles, the travel permission section is granted with respect to a portion before it.

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In the example shown in FIG. 8B, the section where the dump truck 20-1 exists is S0, and a section included in the travel permission granted length L from the distal end of it becomes sections S1, S2, S3, and S4. However, the sections S3 and S4 have been already granted to the dump truck 20-2 as the travel permission section Sb. Therefore, the candidate of the travel permission section that can be newly set for the dump truck 20-1 becomes the sections 51 and S2, however, the section 51 has been already included in the travel permission section Sa that has been set for the dump truck 20-1. Accordingly, the travel permission section setting unit 311b sets the section S2 only as a new travel permission section.

The travel permission section setting unit 311b releases a section where the dump truck 20 has passed out of the sections where the travel permission has been granted at predetermined timing. In concrete terms, when a distance Dc from the distal end of the section S3 that becomes the releasing object to the position of the dump truck 20-2 becomes equal to or longer than a travel permission release distance Db determined beforehand as shown in FIG. 8C, the travel permission section setting unit 311b releases the section S3 from the travel permission section Sb. The section S3 having been released becomes capable of being set as the travel permission section Sa for the dump truck 20-1 following up.

Interference of the dump trucks 20-1 and 20-2 can be prevented by assigning the travel permission sections Sa and Sb as described above. Thus, when the vehicle traveling the travel route 64 is the dump truck 20-1 and 20-2 as an unmanned vehicle, unerring travel within the travel permission sections Sa, Sb becomes possible by the terminal side control device 26. However, when the vehicle is the manned vehicle 70, there is a possibility that the vehicle erroneously enters a travel permission section of other vehicles by overlooking of a display and an instruction by the driver and so on, and therefore the countermeasures for it are necessary.

Therefore, the terminal side control device 761 of the manned vehicle terminal device 76 related to the first embodiment of the present invention has a function as a travel instruction processing device that executes a process for instructing travel of the own vehicle to the driver on the basis of the travel permission section assigned by the control server 31. Also, for the driver of the manned vehicle 70, free travel is allowed basically as far as the manned vehicle 70 travels within the range of the travel permission section assigned to the own vehicle, however, it is required to surely stop within the travel permission section when the own vehicle approaches the distal end of the travel permission section. In this regard, although it is also conceivable to present the distance to the distal end of the travel permission section to the driver of the manned vehicle 70, in general, it is difficult for the driver to stop the own vehicle at a target position only from the numerical value of the distance compared with a case the driver stops the own vehicle while looking at a target object. Therefore, the first embodiment of the present invention shows an example of presenting an upper limit speed that becomes an indication for the driver to stop the own vehicle within a travel permission section.

Below, a concrete configuration showing the function of the manned vehicle terminal device 76 related to the first embodiment of the present invention will be explained in detail referring to FIG. 9 to FIG. 11.

As shown in FIG. 9, the terminal side control device 761 includes a remaining distance calculation unit 761a, an upper limit speed calculation unit 761b, a display control unit 761c, a demand information processing unit 761d, and

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a terminal side communication control unit 761e. Since these demand information processing unit 761d and terminal side communication control unit 761e have a configuration similar to that of the dump terminal device 26, duplicated explanation thereof will be omitted. Also, the position information showing the present position of the own vehicle calculated by the position calculation device 79 that is mounted on the manned vehicle 70 is transmitted to the control server 31 through the terminal side communication control unit 761e. Also, when the manned vehicle 70 is the dump truck 71 where a driver gets on the dump truck 20 having been positioned as an unmanned vehicle, the terminal side control device 761a also includes the autonomous travel control unit 261a that is similar to the dump terminal device 26 in addition to the constituent elements described above.

The remaining distance calculation unit 761a calculates the travel permission remaining distance D on the basis of the present position of the own vehicle calculated by the position calculation device 79 that is connected to the terminal side control device 761a and the travel permission section assigned to the own vehicle by the control server 31.

The upper limit speed calculation unit 761b calculates the upper limit speed of the own vehicle in the travel permission section on the basis of the travel permission remaining distance D calculated by the remaining distance calculation unit 761a. In concrete terms, the upper limit speed calculation unit 761b calculates an upper limit speed  $V_{max}$  as a speed at which the own vehicle travels from a present position N and can stop at a target position (will be hereinafter referred to as "stop target position" for convenience) before the distal end of a travel permission section S by a predetermined margin distance d as shown in FIG. 10, for example. This upper limit speed  $V_{max}$  can be obtained using an expression (3) below.

[Math. 3]

$$V_{max} = \sqrt{\frac{2f_h(D-d)}{M_h}} \quad (1)$$

where

$f_h$ : braking force of manned vehicle

$M_h$ : mass of manned vehicle including load

Accordingly, when the margin distance d is set to the value of 0 beforehand, the upper limit speed  $V_{max}$  can be obtained as a speed stoppable at the distal end of the travel permission section S. Also, the upper limit speed calculation unit 761b may calculate the upper limit speed  $V_{max}$  taking a parameter affecting the braking distance of the own vehicle into account. As such parameter, the inclination of the travel route 64 of the upward slope, downward slope and the like, easiness of sliding of the road surface, and so on can be cited, for example. The inclination of the travel route 64 can be calculated on the basis of the height information of the travel route 64 acquired from the map information, and easiness of sliding of the road surface can be calculated on the basis of information of the climate and a road surface state inputted by a driver using the terminal side input device 762. Also, the braking force  $f_h$  of the manned vehicle 70 may be one that is on the basis of a braking force by the regenerative brake 771, for example. Thus, in calculation of the upper limit speed  $V_{max}$  of the own vehicle by the upper limit speed calculation unit 761b, a calculation result of the

upper limit speed  $V_{max}$  with high accuracy can be obtained by considering a parameter that affects the braking distance of the own vehicle.

The display control unit **761c** functions as an information presentation unit that makes the terminal side display device **763** connected to the terminal side control device **761** output the upper limit speed  $V_{max}$  calculated by the upper limit speed calculation unit **761b** and predetermined warning information corresponding to the upper limit speed  $V_{max}$  and presents the same to the driver.

Next, a process of display control for the upper limit speed  $V_{max}$  and the warning information to the terminal side display device **763b** by the display control unit **761c** will be explained in detail referring to FIG. 11.

As shown in FIG. 11A, 11B, on a display screen of the terminal side display device **763** with respect to the upper limit speed  $V_{max}$ , there are projected a present speed indicator **763a** that shows the present speed of the own vehicle, a proper speed indicator **763b** that shows a speed suitable for the own vehicle to travel within the travel permission section S, that is, a proper speed, and an upper speed indicator **763c** that shows the upper limit speed  $V_{max}$  with respect to the present position N of the own vehicle in the travel permission section S. In the first embodiment of the present invention, the present speed indicator **763a** is formed into a long needle shape, and moves along an arc C1 of a semi-circular shape of the inner side. The proper speed indicator **763b** is formed into a white short needle shape, the upper speed indicator **763c** is formed into a black short needle shape, and these proper speed indicator **763b** and upper speed indicator **763c** move along an arc C2 of a semi-circular shape of the outer side. Also, on the display screen of the terminal side display device **763** with respect to the upper limit speed  $V_{max}$ , scale marks may be provided which allow the driver to grasp a speed corresponding to a position pointed by the respective indicators **763a** to **763c** as a numerical value.

On a display screen of the terminal side display device **763** with respect to the warning information, there are projected a DECELERATE light **763d** for urging the driver to decelerate when the speed of the own vehicle approaches the upper limit speed  $V_{max}$ , a BRAKE light **763e** for urging the driver to positively decelerate using a braking means such as the mechanical brake **772** when the speed of the own vehicle exceeds the upper limit speed  $V_{max}$ , and a STOP light **763f** for urging the driver to stop the own vehicle and continue a stand-by state when the own vehicle approaches the distal end of the travel permission section S and new travel permission section S has not been obtained.

The display control unit **761c** executes control for turning the present speed indicator **763a** clockwise when the speed of the own vehicle detected by the wheel speed sensor **782** increases as shown in FIG. 11A, and for turning the present speed indicator **763a** counterclockwise when the speed of the own vehicle detected by the wheel speed sensor **782** lowers as shown in FIG. 11B. Also, the display control unit **761c** executes control for using the maximum allowable speed of the travel permission section S, for example, as a proper speed of the own vehicle, and turning the proper speed indicator **763b** to a position corresponding to this maximum allowable speed.

Further, the display control unit **761c** executes control for turning the upper speed indicator **763c** clockwise when the upper limit speed  $V_{max}$  calculated by the upper speed calculation unit **761b** increases as shown in FIG. 11A, and for turning the upper speed indicator **763c** counterclockwise when the upper limit speed  $V_{max}$  calculated by the upper

speed calculation unit **761b** lowers as shown in FIG. 11B. Also, when the upper limit speed  $V_{max}$  calculated by the upper speed calculation unit **761b** lowers further, because the proper speed of the own vehicle agrees to the upper limit speed  $V_{max}$ , the proper speed indicator **763b** and the upper speed indicator **763c** turn counterclockwise together while overlapping to each other accompanying drop of the upper limit speed  $V_{max}$ .

The display control unit **761c** executes control for turning on the DECELERATE light **763d** when the speed of the own vehicle detected by the wheel speed sensor **782** is equal to or higher than a predetermined warning speed  $V_a$ , and for turning off the DECELERATE light **763d** when the speed of the own vehicle detected by the wheel speed sensor **782** is lower than the warning speed  $V_a$ . Said warning speed  $V_a$  is set, for example, to a value obtained by deducting a predetermined margin speed  $V_m$  from the upper limit speed  $V_{max}$  ( $V_a = V_{max} - V_m$ ).

The display control unit **761c** executes control for turning on the BRAKE light **763e** when the speed of the own vehicle detected by the wheel speed sensor **782** is equal to or higher than the upper limit speed  $V_{max}$  and for turning off the BRAKE light **763e** when the speed of the own vehicle detected by the wheel speed sensor **782** is lower than the upper limit speed  $V_{max}$ .

Also, the display control unit **761c** executes control for turning on the STOP light **763f** when the travel permission remaining distance D calculated by the remaining distance calculation unit **761a** is equal to or less than a predetermined threshold value  $D_s$  (refer to FIG. 10), and for turning off the STOP light **763f** when the travel permission remaining distance D calculated by the remaining distance calculation unit **761a** is greater than the threshold value  $D_s$ . In other words, the display control unit **761c** presents stop information urging stop of the own vehicle by turning on the STOP light **763f**. Said threshold value  $D_s$  is determined beforehand to a distance from the distal end of the travel permission section S to a position set to be front of the target stop position (will be hereinafter referred to as "target arrival determination distance" for convenience) as shown in FIG. 10, for example, and the manned vehicle **70** comes to have reached the vicinity of the target stop position at the time point the travel permission remaining distance D has become equal to or shorter than this target arrival determination distance  $D_s$ .

The remaining distance calculation unit **761a**, the upper limit speed calculation unit **761b**, the display control unit **761c**, the demand information processing unit **761d**, and the terminal side communication control unit **761e** included in the manned vehicle terminal device **76** configured thus are achieved by that the programs achieving the functions of them are executed by the terminal side control device **761** (hardware) shown in FIG. 6.

Next, the processing motions of the manned vehicle terminal device **76** related to the first embodiment of the present invention will be explained in detail on the basis of a flowchart of FIG. 12.

First, the demand information processing unit **761d** of the terminal side control device **761** in the manned vehicle terminal device **76** inputs the calculation result of the remaining distance calculation unit **761a** of the terminal side control device **761**, and determines whether the travel permission remaining distance D calculated by the remaining distance calculation unit **761a** is equal to or shorter than the travel permission demand start distance  $D_a$  (step (will be hereinafter written as "S") **1201**). At this time, when it is determined that the travel permission remaining distance D

is longer than the travel permission demand start distance  $D_a$  (S1201/NO), the demand information processing unit **761d** does not update the travel permission, and proceeds to the process S1203 described below.

In S1201, when it is determined that the travel permission remaining distance  $D$  is equal to or shorter than the travel permission demand start distance  $D_a$  (S1201/YES), the demand information processing unit **761d** transmits the section demand information to the control server **31** through the terminal side communication control unit **761e** and the terminal side communication device **764**, and new travel permission section  $S$  is thereby obtained from the control server **31** for updating (S1202).

Next, the upper limit speed calculation unit **761b** of the terminal side control device **761** inputs the calculation result of the remaining distance calculation unit **761a**, and determines whether the travel permission remaining distance  $D$  calculated by the remaining distance calculation unit **761a** is longer than the target arrival determination distance  $D_s$  (S1203). At this time, when it is determined that the travel permission remaining distance  $D$  is longer than the target arrival determination distance  $D_s$  (S1203/YES), the upper limit speed calculation unit **761b** calculates the upper limit speed  $V_{max}$  of the own vehicle in the travel permission section  $S$  on the basis of the travel permission remaining distance  $D$  (S1204), and the calculation result thereof is outputted to the display control unit **761c** of the terminal side control device **761**.

Next, the display control unit **761c** inputs the calculation result of the upper limit speed calculation unit **761b**, deducts the margin speed  $V_m$  from the upper limit speed  $V_{max}$  calculated by the upper limit speed calculation unit **761b**, and calculates the warning speed  $V_a$  (S1205). Also, the display control unit **761c** inputs the detection result of the wheel speed sensor **782**, and determines whether a speed  $V$  of the own vehicle detected by the wheel speed sensor **782** is less than the warning speed  $V_a$  (S1206). At this time, when it is determined that the speed  $V$  of the own vehicle is less than the warning speed  $V_a$  (S1206/YES), the display control unit **761c** turns off the DECELERATE light **763d**, the BRAKE light **763e**, and the STOP light **763f**, and the process from S1201 is thereafter repeated.

On the other hand, when it is determined that the speed  $V$  of the own vehicle is equal to or higher than the warning speed  $V_a$  in S1206 (S1206/NO), the display control unit **761c** determines whether the speed  $V$  of the own vehicle is lower than the upper limit speed  $V_{max}$  (S1207). At this time, when it is determined that the speed  $V$  of the own vehicle is lower than the upper limit speed  $V_{max}$  (S1207/YES), the display control unit **761c** turns on the DECELERATE light **763d** (S1208), and the process from S1201 is repeated. Thereby, the driver of the manned vehicle **70** confirms the display screen of the terminal side display device **763**, accelerates or decelerates the own vehicle according to presence/absence of turning on of the DECELERATE light **763d**, and can thereby stop the own vehicle without running off the inside of the travel permission section  $S$ .

When it is determined that the speed  $V$  of the own vehicle is equal to or higher than the upper limit speed  $V_{max}$  in S1207, (S1207/NO), the display control unit **761c** turns on the BRAKE light **763e** (S1209), and the process from S1201 is repeated. Also, when it is determined that the travel permission remaining distance  $D$  is equal to or shorter than the target arrival determination distance  $D_s$  in S1203 (S1203/NO), the upper limit speed calculation unit **761b** turns on the STOP light **763f** (S1210), and the process from S1201 is repeated.

Therefore, when the driver of the manned vehicle **70** stops the own vehicle at a position extremely before the distal end of the travel permission section  $S$ , because the STOP light **763f** has been turned off, the driver accelerates or decelerates the own vehicle while confirming the respective indicators **763a** to **763c** projected on the display screen of the terminal side display device **763**, and thereby can make the own vehicle travel efficiently within the travel permission section  $S$ . Also, the driver stops the own vehicle at a time point the STOP light **763f** is turned on, and the own vehicle can thereby stand by at a proper position until new travel permission section  $S$  is obtained. Further, when the own vehicle obtains new travel permission section  $S$ , the STOP light **763f** is turned off again, and therefore the driver can start travel of the own vehicle smoothly.

According to the traffic control system **1** and the manned vehicle terminal device **76** related to the first embodiment of the present invention configured thus, the process of instructing travel of the own vehicle to the driver after acquiring the new travel permission section  $S$  from the control server **31** is executed by the manned vehicle terminal device **76**. Therefore, even when a problem occurs in the communication condition such as interruption of communication between the dump truck **20**, the manned vehicle **70** and the control server **31**, and so on, by confirming each of the indicators **763a** to **763c** and the lights **763d** to **763f** of the display screen of the terminal side display device **763**, the driver of the manned vehicle **70** can make the own vehicle travel stably to the end of the travel permission section  $S$ . Thus, even when a problem occurs in the communication condition, interference of the dump truck **20** and the manned vehicle **70** can be suppressed, and the working efficiency can be improved.

Also, in the first embodiment of the present invention, the upper limit speed  $V_{max}$  indicated by the upper limit speed indicator **763c** projected on the display screen of the terminal side display device **763** shows a speed at which the own vehicle travels from the present position  $N$  and can stop at a target stop position before the distal end of the travel permission section  $S$  by the margin distance  $d$ , and therefore the driver can prevent the own vehicle from running off the inside of the travel permission section  $S$  by adjusting the speed of the own vehicle so that the present speed indicator **763a** does not exceed the upper limit speed indicator **763c**.

#### Second Embodiment

Next, the configuration of a manned vehicle terminal device **76A** related to a second embodiment of the present invention will be explained in detail referring to FIG. **13** and FIG. **14**.

In the manned vehicle terminal device **76A** related to the second embodiment of the present invention, in addition to the configuration of the first embodiment described above, as shown in FIG. **13**, a speed display part **763g** that displays a speed by a numerical value is projected on the display screen of the terminal side display device **763** with respect to the upper limit speed  $V_{max}$ , the speed being shown by at least one of the present speed indicator **763a**, the proper speed indicator **763b**, and the upper speed indicator **763c**.

In this case, a display control unit **761c1** related to the second embodiment of the present invention executes control of switching display of the speed display part **763g** to a speed selected by the driver of the manned vehicle **70** out of the present speed, the proper speed, and the upper limit speed  $V_{max}$  of the own vehicle according to operation of the terminal side input device **762** by the driver. Also, in an

example shown in FIG. 13, the upper limit speed  $V_{max}$  is displayed to be 50 km/h in the speed display part 763g. Other configurations of the second embodiment are same to those of the first embodiment, a portion duplicating with or corresponding to that of the first embodiment is marked with a same reference sign, and duplicated explanation thereof is omitted.

According to the manned vehicle terminal device 76A related to the second embodiment of the present invention, in addition to that actions and effects similar to those of the first embodiment described above are obtained, the driver of the manned vehicle 70 not only can sensuously grasp information on the speed of the own vehicle from the respective indicators 763a to 763c on the display screen of the terminal side display device 763, but also can precisely grasp information of the speed selected using the terminal side input device 762 from the speed display part 763g on the display screen of the terminal side display device 763. Thus, travel of the own vehicle with high accuracy by a driver can be achieved.

Also, the present embodiments described above have been explained in detail for easy understanding of the present invention, and are not necessarily limited to those including all configurations explained. Furthermore, a part of a configuration of a certain embodiment can be replaced by a configuration of other embodiments, and a configuration of other embodiments can be also added to a configuration of a certain embodiment.

Also, in the present embodiments, when a number and the like (inclusive of number of pieces, numerical value, volume, range, and the like) of an element is mentioned, the number and the like of the element is not limited to the specific number but may be equal to and more than and equal to and less than the specific number excluding a case specifically stated and a case apparently limited to a specific number in principle, and so on. In addition, a constituent element (inclusive of a processing motion and the like) included in the present embodiments is not necessarily indispensable but may possibly be omitted properly excluding a case specifically stated and a case considered to be apparently indispensable in principle, and so on.

Furthermore, although the manned vehicle terminal devices 76, 76A related to the present embodiments were explained with respect to the case the upper limit speed  $V_{max}$  of the own vehicle and the warning information were presented to the driver using the respective indicators 763a to 763c and the respective lights 763d to 763f projected on the display screen of the terminal side display device 763, the manned vehicle terminal devices 76, 76A are not limited to this case, and it is also possible that a voice capable of discriminatingly grasping these upper limit speed  $V_{max}$  and warning information is outputted, or that such voice and the respective indicators 763a to 763c and lights 763d to 763f are combined.

#### LIST OF REFERENCE SIGNS

1 . . . traffic control system, 20, 20-1, 20-2 . . . dump truck (unmanned vehicle), 30 . . . control center, 31 . . . control server (traffic control server), 40 . . . radio communication channel, 50-1, 50-2, 50-3 navigation satellite (position acquiring device), 64 . . . travel route, 70 . . . manned vehicle, 71 . . . dump truck, 72 . . . service car, 76, 76A . . . manned vehicle terminal device (onboard terminal device), 77 . . . vehicle control device, 78 . . . sensor device, 79 . . . position calculation device (position acquiring device), 311 . . . server side control device, 311a . . . vehicle dispatch managing unit,

311b . . . travel permission section setting unit, 311c . . . travel control unit, 311d . . . server side communication control unit, 761 . . . terminal side control device (travel instruction processing device), 761a . . . remaining distance calculation unit, 761b . . . upper limit speed calculation unit, 761c, 761c1 . . . display control unit (information presentation unit), 761d . . . demand information processing unit, 761e . . . terminal side communication control unit, 762 . . . terminal side input device, 763 . . . terminal side display device (output device), 763a . . . present speed indicator, 763b . . . proper speed indicator, 763c . . . upper limit speed indicator, 763d . . . DECELERATE light, 763e . . . BRAKE light, 763f . . . STOP light, 763g . . . speed indication part, 764 . . . terminal side communication device, 765 . . . communication bus, 766 . . . terminal side map information DB, 771 . . . regenerative brake, 772 . . . mechanical brake, 773 . . . steering control device, 774 . . . acceleration control device, 781 . . . environmental sensor, 782 . . . wheel speed sensor

The invention claimed is:

1. An onboard terminal device that is connected to a traffic control server through a radio communication channel, the traffic control server conducting traffic control for avoiding interference between vehicles including a manned vehicle and an unmanned vehicle that travels autonomously in a mine, and the onboard terminal device is mounted on the manned vehicle operated by a driver, comprising:

a travel instruction processing device that is configured to conduct processing for instructing the driver on travel of the manned vehicle based on a travel permission section where a partial section of a travel route of the vehicle is assigned by the traffic control server as a section permitted for the manned vehicle to travel, wherein the travel instruction processing device is further configured to:

calculate a travel permission remaining distance between a present position of the manned vehicle to an end of the travel permission section along the travel route on the basis of the travel permission section and the present position of the manned vehicle which is acquired from a position acquiring device that is connected to the travel instruction processing device;

calculate an upper limit speed of the manned vehicle in the travel permission section on the basis of the travel permission remaining distance; and

cause an output device connected to the travel instruction processing device to output and present to the driver a speed display area and a warning information display area which is displayed side by side with the speed display area,

wherein a first marker indicating a predefined allowable speed in the travel permission section, a second marker indicating the upper limit speed, and a pointer indicating a current speed of the manned vehicle are displayed in the speed display area,

wherein the marker indicating the allowable speed and the marker indicating the upper limit speed are arranged on a same circumference of the speed display area and move independently along the circumference, and wherein predetermined warning information corresponding to the upper limit speed is displayed in the warning information display area.

2. The onboard terminal device according to claim 1, wherein stop information is displayed in the warning information display area to urge the manned vehicle to stop when



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the travel permission remaining distance is equal to or less than a predetermined threshold value.

3. The onboard terminal device according to claim 1, wherein

the upper limit speed is calculated as a speed at which the manned vehicle travels from the present position and can stop at a target position before the end of the travel permission section by a predetermined distance.

4. The onboard terminal device according to claim 1, wherein

the upper limit speed is calculated based on a parameter that affects a braking distance of the manned vehicle.

5. A traffic control system, comprising:

a traffic control server configured to conduct traffic control for avoiding interference between vehicles including a manned vehicle operated by a driver and an unmanned vehicle that travels autonomously in a mine; and

an onboard terminal device that is connected to the traffic control server through a radio communication channel and is mounted on the manned vehicle

wherein the traffic control server is further configured to set a partial section of a travel route of the manned vehicle as a travel permission section permitted for the manned vehicle to travel,

wherein the onboard terminal device comprises a travel instruction processing device that is configured to conduct processing for instructing the driver on travel of the manned vehicle based on the travel permission section, and

wherein the travel instruction processing device is further configured to:

calculate a travel permission remaining distance between a present position of the manned vehicle to an end of the travel permission section along the travel route on the basis of the present position of the manned vehicle acquired from a position acquiring device that is con-

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nected to the travel instruction processing device and the travel permission section;

calculate an upper limit speed of the manned vehicle in the travel permission section on the basis of the travel permission remaining distance; and

cause an output device connected to the travel instruction processing device to output and present to the driver a speed display area and a warning information display area which is displayed side by side with the speed display area,

wherein a first marker indicating a predefined allowable speed in the travel permission section, a second marker indicating the upper limit speed, and a pointer indicating a current speed of the manned vehicle are displayed in the speed display area,

wherein the marker indicating the allowable speed and the marker indicating the upper limit speed are arranged on a same circumference of the speed display area and move independently along the circumference, and

wherein predetermined warning information corresponding to the upper limit speed is displayed in the warning information display area.

6. The onboard terminal device according to claim 1, wherein a pointed tip of the pointer indicating the current speed moves on a movement path of a pointed tip of the first marker indicating the allowable speed and a pointed tip of the second marker indicating the upper limit speed.

7. The onboard terminal device according to claim 1, wherein deceleration information is displayed in the warning information display area to urge the manned vehicle to decelerate when the current speed of the manned vehicle approaches or exceeds the upper limit speed, and stop information is displayed in the warning information display area to urge the manned vehicle to stop when the manned vehicle approaches the end of the travel permission section.

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